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GOVERNMENT DOCUMENTS

WINDERMERE BASIN REHABILITATION PROJECT

INITIAL ASSESSMENT FOR THE PARTIAL DREDGING AND FILLING
OF WINDERMERE BASIN

Prepared under the

FEDERAL ENVIRONMENTAL ASSESSMENT and REVIEW PROCESS

Prepared For

Public Works Canada

and

Hamilton Harbour Commissioners

May 20, 1988

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PREFACE

Investigations by Environment Canada, the Ontario Ministry of Environment, the Windermere Basin Technical Advisory Committee and others have illustrated the need for a clean-up of the Windermere Basin which is located in the southeast corner of Hamilton Harbour.

The Hamilton Harbour Commissioners have initiated the preparatory work necessary to develop a detailed programme for the clean-up of the Windermere Basin in accordance with the Windermere Basin Technical Advisory Committee recommendations.

This document is prepared as an Initial Assessment under the Federal Environmental Assessment and Review Process. This document provides the necessary environmental evaluation information in accordance with the requirements set out by the Federal Environmental Assessment Review Office (FEARO) and Environment Canada Ontario Region.

As the originating agency, the Hamilton Harbour Commissioners have requested Public Works Canada to have undertaken the preparation of this document including conducting consultations with other Canada and Ontario government departments and agencies and the public.

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1.0 INTRODUCTION

A clean-up of the Windermere Basin is to be undertaken by a joint group of agencies led by the Hamilton Harbour Commissioners with the proposed works being reviewed under the Federal Environmental Assessment and Review Process (EARP). The proposed clean-up is to be accomplished by dredging a portion of the Windermere Basin and disposing of the dredged material in confined disposal areas located within the Basin, essentially in accordance with the rehabilitation alternative developed among the parties represented on the Windermere Basin Technical Advisory Committee.

This document describes and evaluates environmental consequences for undertaking the project. The selected alternative for the project is discussed including the mitigative measures that can be undertaken to ensure that the project does not adversely impact the surrounding environment. The alternative approaches considered to undertake the clean-up of Windermere Basin are reviewed and the related environmental factors including the positive and negative benefits are explained for each alternative.

This Screening Report is prepared as per the approach outlined in the Federal Environmental Assessment and Review Process (EARP) guideline 'INITIAL ASSESSMENT GUIDE'. Requirements specific to this project were identified by Environment Canada are addressed.

The first part of this Screening Report provides information obtained from a review of previous documents and reports related to the project. These documents and reports are identified in the References.

The second part of the Screening Report describes the detailed approach to be taken to implement the project with specific information outlining the mitigative measures to be incorporated to safeguard the surrounding environment. The information describing the project details has been discussed with representatives of interested parties including:

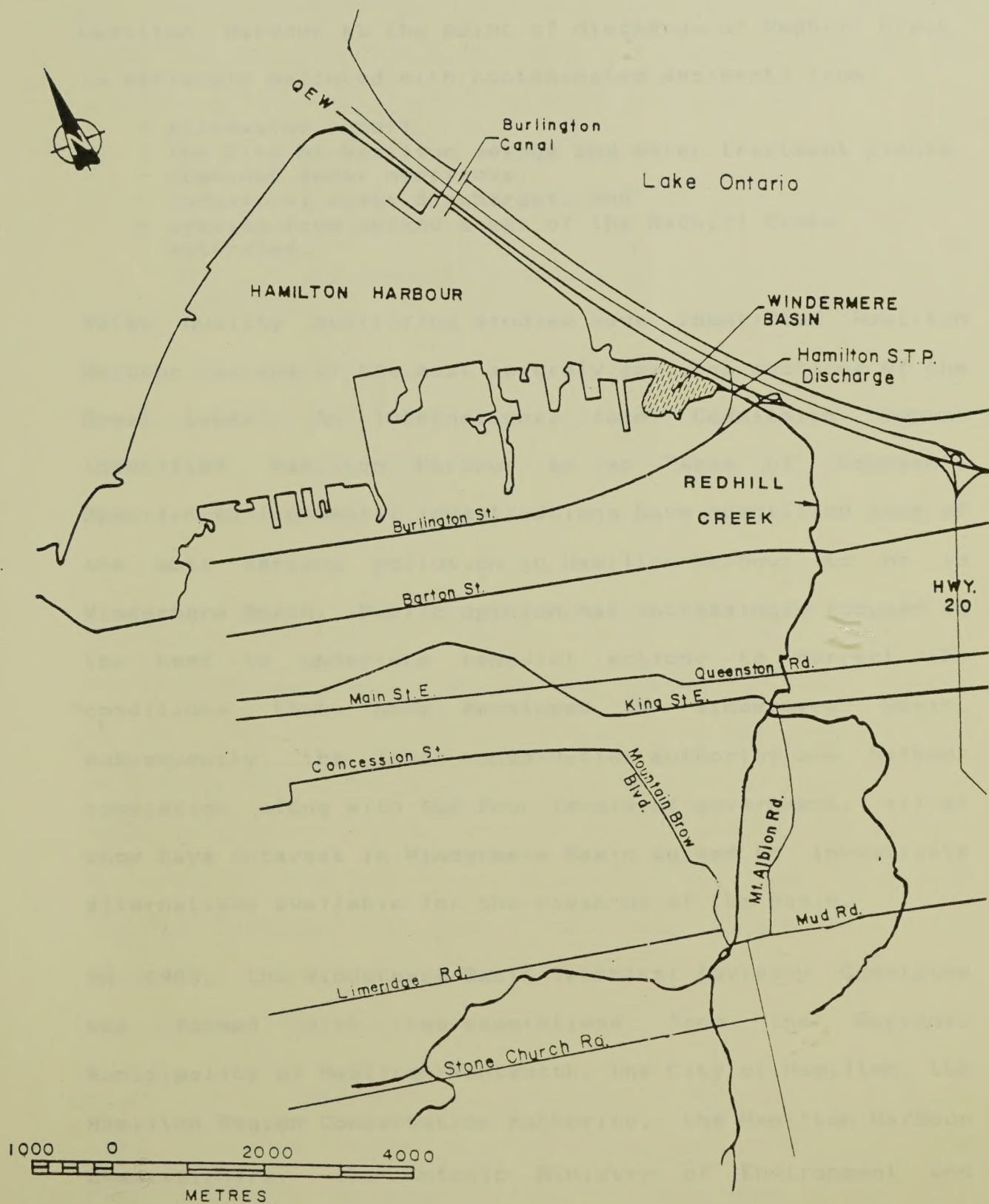
- Public Works Canada,
- Mar-land Engineering,
- Environment Canada,
- Hamilton Harbour Commissioners,
- Ontario Ministry of Environment,
- Canadian Wildlife Service,
- Hamilton Naturalists Club,

Discussions have not yet been held with:

- Ontario Ministry of Natural Resources,
- Hamilton Region Conservation Authority,
- Region of Hamilton-Wentworth,
- City of Hamilton,
- public and concerned groups at 2 open house sessions.

Concerns expressed have been reviewed and remedial measures developed to mitigate the environmental problems that have been identified. A monitoring programme that will measure and test environmental quality against established benchmarks is described.

REDHILL CREEK, WINDERMERE BASIN DRAINAGE SYSTEM



From - Windermere Basin Study (MOE, 1982)

2.0 BACKGROUND TO THE PROJECT

The Windermere Basin, located at the southeast extremity of Hamilton Harbour at the point of discharge of Redhill Creek, is seriously polluted with contaminated sediments from:

- stormwater runoff,
- the City of Hamilton sewage and water treatment plants,
- combined sewer overflows,
- industrial waste discharges, and
- erosion from upland areas of the Redhill Creek watershed.

Water quality monitoring studies have identified Hamilton Harbour as one of the most severely polluted sections of the Great Lakes. An International Joint Commission report identified Hamilton Harbour as an "Area of Concern". Specific environmental investigations have identified some of the most serious pollution in Hamilton Harbour to be in Windermere Basin. Public opinion has increasingly focused on the need to undertake remedial actions to correct the conditions that have developed in Windermere Basin. Subsequently, the local conservation authority and harbour commission along with the four levels of government, all of whom have interest in Windermere Basin agreed to investigate alternatives available for the clean-up of the Basin.

In 1983, the Windermere Basin Technical Advisory Committee was formed with representatives from the Regional Municipality of Hamilton-Wentworth, the City of Hamilton, the Hamilton Region Conservation Authority, the Hamilton Harbour Commissioners, the Ontario Ministry of Environment and Environment Canada. The Committee undertook to find a

solution to facilitate the clean-up of the Basin.

The final report of the Windermere Basin Technical Advisory Committee entitled 'The Dredging of the Windermere Basin and the Disposal of Contaminated Sediments' recommends:

- "1. That the basin be partially dredged
2. That the sediments be disposed of on site behind containment berms
3. That the sediments be disposed of without chemical stabilization."

The following sections provide additional background information relating to the project including the findings of previous investigators as well as the major public concerns and perceptions relating to the Windermere Basin.

2.1 EVOLUTION OF THE WINDERMERE BASIN POLLUTION PROBLEM

The land reclamation activities that commenced in the 1950's to facilitate further industrialization in Hamilton resulted in the filling of large portions of the southerly sections of Hamilton Harbour. This land reclamation and the development of the East Port facilities adjacent to the Queen Elizabeth Highway combined to create what has become known as Windermere Basin, an enclosed basin of 47 hectares located at the mouth of the Redhill Creek.

Historically, the principal loadings to the Windermere Basin were from the sediment materials that were discharged from Redhill Creek. As sewer systems were developed in the City

of Hamilton, combined sewer overflow structures were constructed directly to Windermere Basin at Parkdale Avenue and indirectly via Redhill Creek. The locations of some of the discharge structures to Redhill Creek included Greenhill Avenue, Lawrence Road, Queenston Road and Barton Street (MOE 82). This increased the contaminant loading to Windermere Basin and contributed to the accumulation rate of polluted sediments in the basin.

In the 1930's, the City of Hamilton Water Treatment plant was constructed. The plant design included water filters that required intermittent backwashing. This backwash water was discharged to Redhill Creek and subsequently to Windermere Basin, further adding to the sediment and contaminant load.

In the early 1960's, the City of Hamilton undertook the planning and the subsequent construction of sewage collection and treatment facilities. This included the construction of a sanitary sewer interceptor that diverted sewage discharges from several locations along the waterfront to the Windermere Basin. The Woodward Avenue Sewage Treatment Plant was constructed and went into service in 1963 as a 270,000 cubic metre per day (60 million gallon per day (mgd)) primary plant with the effluent being discharged to the Windermere Basin via Redhill Creek. In 1973 conversion of the Woodward Avenue Sewage Treatment Plant to secondary treatment was completed. In 1979, the capacity of the secondary aeration portion of the plant was increased to 405,000 cubic metres per day (90 mgd). However the plant failed to achieve a significant

reduction in organic loading until 1980 when a major operations study was completed and plant operations were modified to achieve full secondary treatment potential including the reduction of phosphorus concentrations in the effluent to in the order of 1.5 mg./L.

In 1981, backwash water from the Hamilton Water Treatment Plant was diverted from Redhill Creek to the Woodward Avenue Sewage Treatment Plant.

Through the selective addition of industrial wastes to the sewage stream, it was possible to reduce the phosphorus concentration in the effluent from the Woodward Avenue Sewage Treatment Plant to approximately 0.6 to 0.7 mg./L. over the period from 1982 to 1985. Following 1985, phosphorus concentrations in the effluent increased. Currently investigations are underway to determine what must be done to re-establish the previous 1982 to 1985 phosphorus removal efficiency at the plant.

To reduce the discharge of pollutants from combined sewer overflow structures, a stormwater management programme has been instituted in Hamilton. This programme has included the construction of a holding facility to retain combined sewage overflows at Greenhill Avenue. Hamilton engineering staff estimate that this structure will eliminate the discharge of 95% of the BOD and suspended solids currently being discharged to the Redhill Creek from the Greenhill combined sewer by-pass. The Greenhill combined sewer by-pass has

traditionally represented in the order of 70% of the combined sewage by-passing to the Redhill Creek. This facility could foreseeably lead to a 60% to 70% reduction in the combined sewer bypass loadings to Redhill Creek. In addition, the Region of Hamilton Wentworth has reduced the by-passing of combined sewage directly to the Windermere Basin by increasing maximum flows through the primary portion of the Woodward Avenue Sewage Treatment Plant before opting for a by-pass. This has led to an increased average daily flow being treated at the plant. In 1982 the average daily treatment was in the order of 62 to 63 mgd. In 1987 the average daily flow was approaching 75 mgd.

From the 1930's to 1981, the Windermere Basin received solids from backwashing water treatment plant filters. Over the period from the 1950's to date, the Windermere Basin has been the point of discharge for additional loadings as discussed above. The net result has been the accumulation of contaminated sediments throughout the Basin. The programmes now underway are reducing those loadings significantly.

2.2 WINDERMERE BASIN LOADINGS

Previous studies have identified the source and quantity of a number of pollutants being discharged to Windermere Basin.

The Ministry of the Environment - Windermere Basin Study (1982) indicates that the total discharges to Windermere Basin averaged 286,000 cubic metres per day of which 245,000

cubic metres per day (85.7%) was effluent from the Woodward Avenue Sewage Treatment Plant, 37,000 cubic metres per day (12.9%) was streamflow from Redhill Creek and 4,000 cubic metres per day (1.4%) was untreated combined sewage overflows discharged directly to the Windermere Basin. The data indicate that on the average, 67.5% of the suspended solids, 11.6% of the total phosphorus and 8.9% of the biochemical oxygen demand loadings to Windermere Basin were from Redhill Creek. The remaining 32.5% of the suspended solids, 88.4% of the total phosphorus and 91.1% of the biochemical oxygen demand loadings were from the treated effluent from the Woodward Avenue Sewage Treatment Plant plus the combined sewer by-passes directly to the Windermere Basin. These loadings are summarized in Table 2.3 of the Windermere Basin Study presented herein as Table 1.

Since 1982, there have been some improvements in treatment at the Woodward Avenue Sewage Treatment Plant along with the construction of a large stormwater holding tank facility upstream at the Greenhill Avenue combined sewer overflow, the latter facility being designed to reduce the quantity of combined sewer by-pass flow to the Redhill Creek. As indicated previously, these improvements have resulted in some loading reductions. As additional improvements are completed, further enhancement of water quality in the Windermere Basin will result.

2.3 MAGNITUDE OF WINDERMERE BASIN CONTAMINATION

As part of the Initial Assessment, Envirosearch undertook an analysis of previous studies that addressed the problem of the accumulated sediments in Windermere Basin. These investigations dealt with the environment of Windermere Basin with attention focussed on water and sediment quality. The potential for contaminants leaching from a confined sediment disposal area was investigated by the Wastewater Technology Centre of Environment Canada. The potential for the sediments to be scoured from the basin under specific conditions was previously reported by Envirosearch (1985).

The findings of the previous work are reviewed below in the order of:

- water quality
- sediment quality
- sediment mobility.

2.3.1 Water Quality

As part of the 1985 Envirosearch study, water quality data (including total phosphorus, total Kjeldahl nitrogen, phenolics, BOD-5, aluminum, cadmium, chromium, copper, nickel, lead and zinc) were analysed for Windermere Basin, Redhill Creek and the discharge channel from the Basin. The Envirosearch study found that concentrations of a number of the parameters including total Kjeldahl nitrogen, aluminum, chromium, copper, nickel, lead and zinc all increased with travel through the initial portion of the basin. From approximately the midpoint of the basin to the outlet these

parameters then reduced in concentration. The total phosphorus and phenolics analyses showed a similar trend, however, the peak concentrations occurred closer to the inflow to the Basin. No clear trends were evident for BOD-5 and cadmium concentrations. The suspended solids analysis indicated higher levels in Redhill Creek upstream from the Woodward Avenue Sewage Treatment Plant than in the plant effluent. Suspended solids were then observed to increase with travel through the initial portion of the basin. From approximately the midpoint of the basin to the outlet the suspended solids reduced in concentration similar to the previous findings for other water quality parameters. The apparent increase in concentration of pollutants in the water column followed by a decrease in concentration was reported as a possible resuspension mechanism in action in the basin whereby pollutants are being released from the sediments into the water column. Presumably, this would be a scour-related phenomenon in which the degree of change in the various parameters with travel through the basin varied with the level of flow. Typically, the most severe changes accompanied high flow conditions. The reduction in concentrations in the downstream area of the basin was attributed to the basin assimilating pollutants in the water column in this portion of the basin. Presumably, if the sediments were not present to be scoured and the initial increase in pollutant concentrations did not occur, the water quality at the outlet from the basin would be significantly better than the incoming quality. No specific investigations

were undertaken to confirm the preceding hypothesis.

The Envirosearch study also illustrated the significance of Redhill Creek in contributing suspended solids to the Windermere Basin sediments. On one occasion following a heavy rainfall, the concentration of suspended solids in Redhill Creek increased fivefold from an average dry weather level of 16 mg/l to 90 mg/l. At the same time, the Woodward Avenue Sewage Treatment Plant suspended solids concentration increased only 50% from an average dry weather level of 12 to 19 mg/l. The suspended solids level then decreased with distance travelled through the basin. During this storm event Windermere Basin entrapped some suspended solids, however, most of the suspended solids loading flowed through to Hamilton Harbour.

Envirosearch reported that PCB's were detected in the water column in Windermere Basin in concentrations ranging from 25 to 90 ug/L. The Ontario Ministry of Environment 1985 report 'Hamilton Harbour, Technical Summary and General Management Options' stated that:

"PCB's were seldom detected (sensitivity 0.02 ug/L) in Red Hill Creek. During runoff, PCB concentrations up to 0.05 ug/L were found."

The same Ontario Ministry of Environment study identified approximately 40 polynuclear aromatic hydrocarbons (PAH's) at concentrations in the range of 0.02 to 0.3 ug/L in the Woodward Avenue Sewage Treatment Plant effluent discharging to Windermere Basin. No data were available on the

concentrations of these parameters at the discharge from the basin.

Envirosearch calculated total oxygen demand at the input to and the outlet from the Basin. The average daily flows from the Woodward Avenue Sewage Treatment Plant and Redhill Creek (stream gauging station no. 02HA014) were used in conjunction with the total Kjeldahl nitrogen and BOD-5 data. Envirosearch used the relationship that equated the total oxygen demand to the sum of the ultimate biochemical oxygen demand (BOD) plus the nitrogenous oxygen demand. The ultimate BOD was assumed to equal the BOD-5 $\times$ 2 and the nitrogenous oxygen demand to equal the total Kjeldahl nitrogen $\times$ 4.57. The report indicated that there was some reduction in the total oxygen demand through the Windermere Basin during periods when the total flowthrough was stable and in the order of 300,000 cubic metres per day or less. As the flow increased during periods of storms the quality in the basin deteriorated, possibly due to sediment scour.

The Hamilton Harbour Technical Summary and General Management Options (August 1985) reported that the Woodward Avenue Sewage Treatment Plant was the major source of BOD, phosphorus and free ammonia loadings to Hamilton Harbour. The report estimated annual pollutant loadings to Hamilton Harbour from known point sources for 1977, 1982 and 1983. The 1977 data indicated 28% of the BOD, 8% of the suspended solids, 44% of the total phosphorus and 67% of the free ammonia loadings to the Harbour were from the Woodward Avenue

Sewage Treatment Plant. The 1982 data indicated 27% of the BOD, 10% of the suspended solids, 69% of the total phosphorus and 75% of the free ammonia loadings to the Harbour were from the sewage treatment plant. A comparison of 1983 loadings from the sewage treatment plant and the Stelco and Dofasco steel operations indicated that the sewage treatment plant contributed BOD loadings equal to 100%, suspended solids loadings equal to 15%, total phosphorus loadings equal to 380% and free ammonia loadings equal to 470% of the steel producers loadings. The report identified the Woodward Avenue Sewage Treatment Plant as a major loading source to the Hamilton Harbour indicating that:

"The Hamilton sewage treatment plant may be a major factor in future algal biomass control through phosphorus limitation in the harbour since it will remain the largest source of phosphorus to the harbour."

The report also went on to indicate that:

"the highest coliform densities are found in the area immediately adjacent to Windermere Basin."

2.3.2 Sediment Quality

The investigations that have been undertaken relating to the quality of sediment in the Windermere Basin indicate serious pollution of the sediments.

The Ontario Ministry of Environment has undertaken a study of the sediment quality at several locations throughout Ontario. This investigation, 'The In Place Pollutants Program - Volume III - Phase 1 Studies' (Persaud et al. 1987) reports the condition of sediments found during the study. The report

stated that:

"in Windermere Basin, the enrichment appears to be due to mainly industrial materials such as solvent extractables (oils and greases)."

The report goes on to explain that:

"Windermere Basin sediment showed excessively high values for all parameters measured (except mercury)"

The In Place Pollutants Program data is substantiated by other investigations.

The efforts to initiate a clean-up of the Hamilton Harbour have resulted in the development of a 'Remedial Action Plan' for the harbour. The reports prepared as part of this plan have discussed the Windermere Basin problem. The 1987 Remedial Action Plan for Hamilton Harbour - Draft Summary Report made specific comments related to Windermere Basin.

The report stated that:

"the predominant problem is the historical deposits of contaminants still present in the sediments of Windermere Basin and in the sediments of the main harbour."

The report also stated that:

"Removal of contaminated sediments in the Windermere Basin is recommended under careful environmental monitoring."

The preceding recommendation supports the proposed Windermere Basin clean-up.

The 1982 Ontario Ministry of Environment Windermere Basin Study indicated that PCB's were distributed in the sediment throughout the Basin. The concentrations of PCB's in the Windermere Basin sediments were compared to the Ontario

guidelines for permissible levels of PCB's in sediment (50 ug/kg) for open water sediment disposal. All Windermere Basin sediment samples were found to contain PCB's in concentrations that exceeded the guideline. The average concentration of PCB's in the sediment was reported to be 1241 ug/kg (ie: 25 times the specified guideline). The maximum concentration of 3430 ug/kg was 68 times the guideline.

The 1985 Envirosearch report found that sediment data collected in 1984 indicated similar quality to the sediments described in the 1982 Windermere Basin Study. The Envirosearch report included the analyses of core samples of the basin sediment that were collected at four locations in 1976. The levels of several metals in two core samples collected near the outlet of Redhill Creek to the Windermere Basin exceeded MOE guideline levels by factors of 20 to 50 in the top 16 centimetres and 10 to 20 between 16 and 60 centimetres with levels approaching the MOE guideline levels at approximately 60 centimetres depth. At 65 centimetres depth the concentration of total nitrogen and organic matter (indicated by the loss on ignition test) increased significantly. This depth of 65 centimetres coincided with the level at which old root material was observed in the sediment by Ontario Ministry of Environment survey staff. The data for a sediment core sample collected in the vicinity of the mudflat near the central portion of the basin showed a similar initial reduction of contaminants but at a depth of

32 centimetres instead of the 16 centimetres previously discussed. At this location there was no indication of increased total nitrogen or organic matter as per the previous core samples. Two core samples located near the outlet from the basin indicated higher levels of pollutants in the top 7 to 8 centimetres with a reduction at lower levels. The location map and bar charts from the 1985 Envirosearch report (Figures 5 through 10) indicating the concentrations of pollutants at specific depths for each location discussed above are presented herein as Figures 1 through 6.

The Envirosearch report suggested that the original level of the bed of the basin (where plant matter was found) was approximately 60 to 65 centimetres below the existing surface of the sediments located near the inlet to the basin. The report suggested that the sediments began to accumulate pollutants as industrialization and development began in the Hamilton area. The significant increase in pollutants at the 16 centimetre depth was thought to possibly correlate to a specific development such as a change in drainage patterns in the Hamilton area possibly through the construction of trunk sewers to discharge to either the Windermere Basin or Redhill Creek.

The Envirosearch report indicated that although there was generally a continuous presence of dissolved oxygen in the water column in the Windermere Basin, the sediments were devoid of oxygen. Hence, it was thought to be possible that

WINDERMERE BASIN

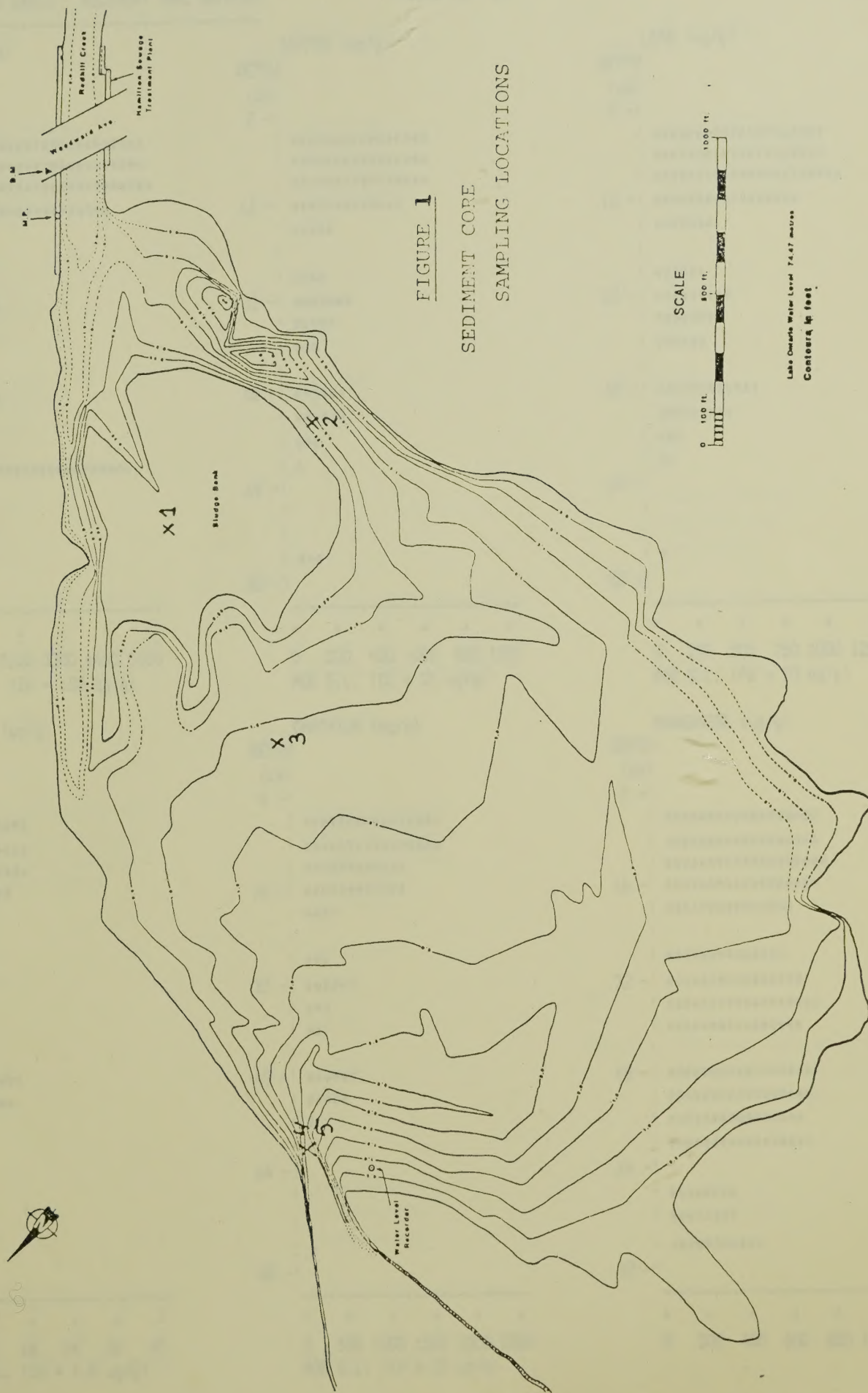


FIGURE 1
SEDIMENT CORE
SAMPLING LOCATIONS

SCALE
0 100 ft 200 ft 1000 ft

Lake Ontario Water Level 74.47 m above
Contours in feet

FIGURE 2

WINDERMERE BASIN - SEDIMENT CORE SAMPLES

(CORE #: 1)

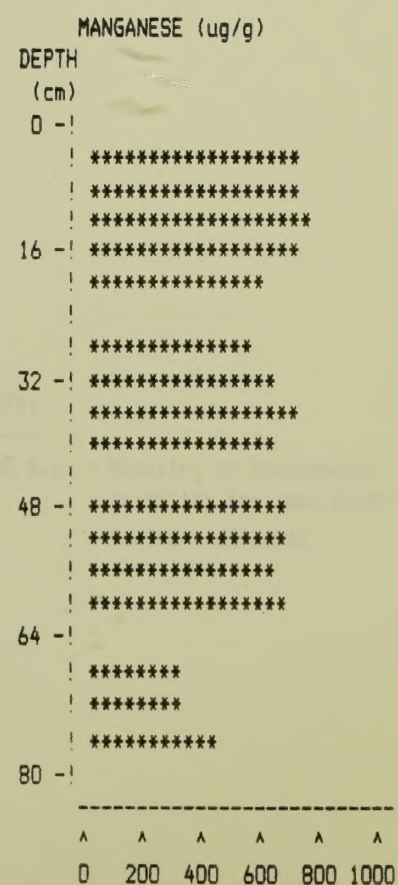
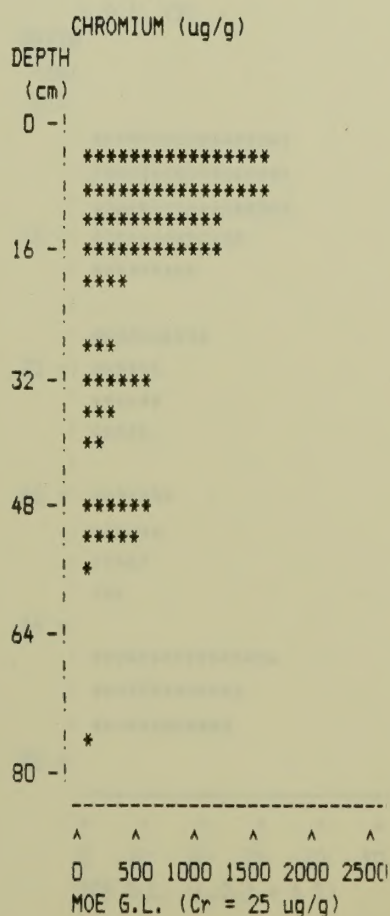
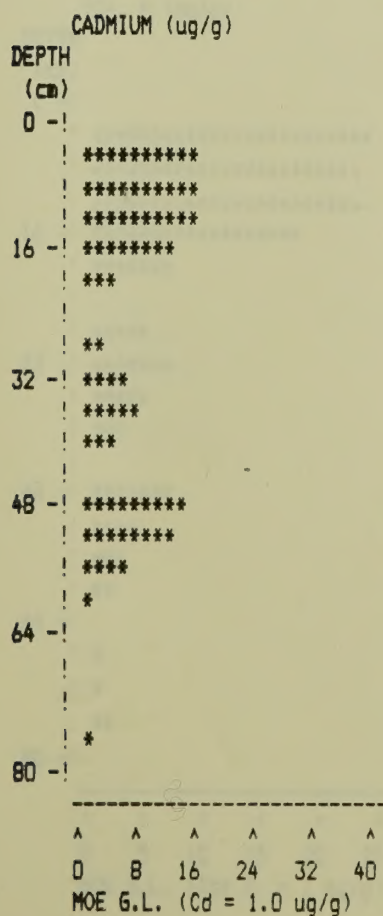
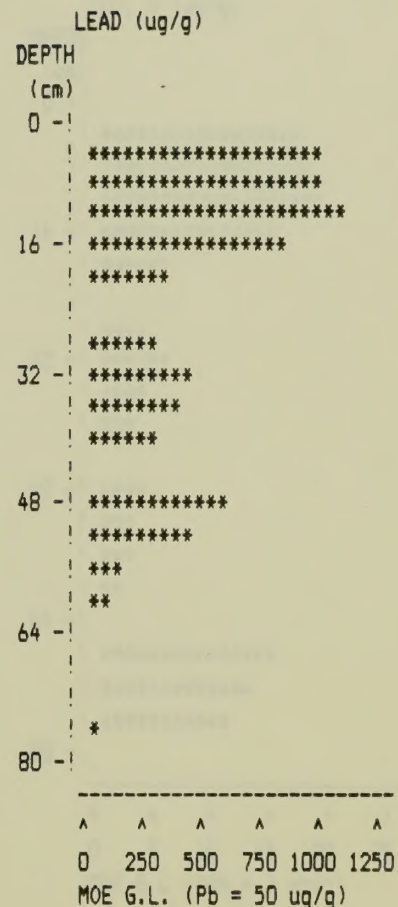
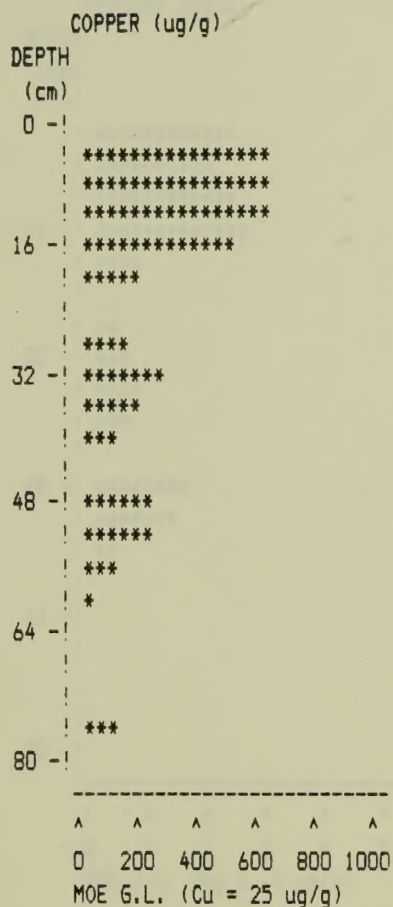
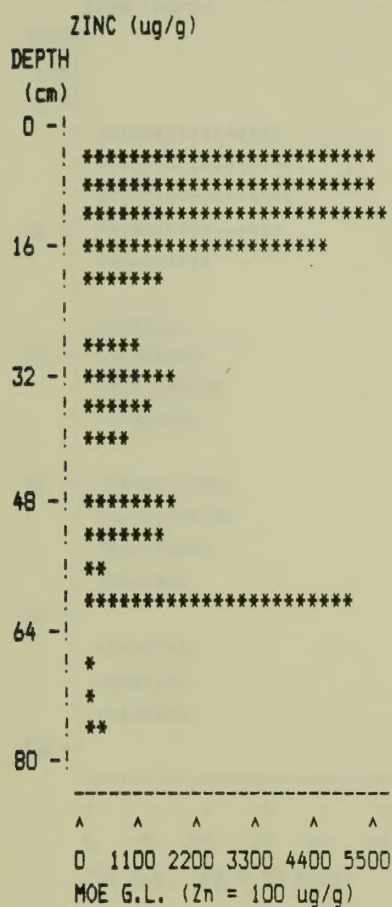
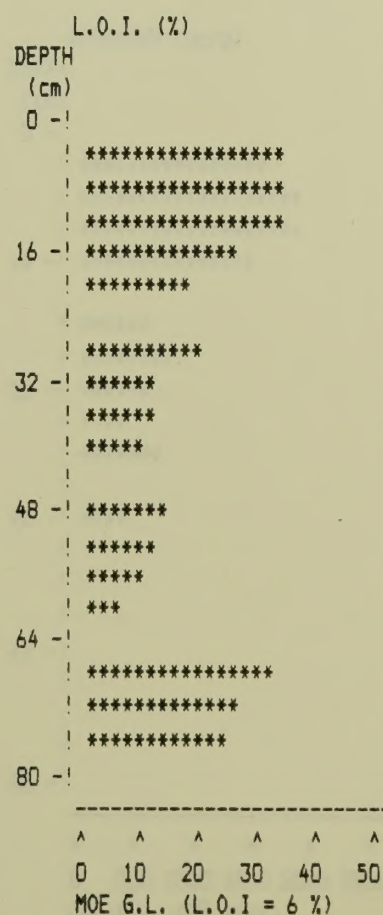
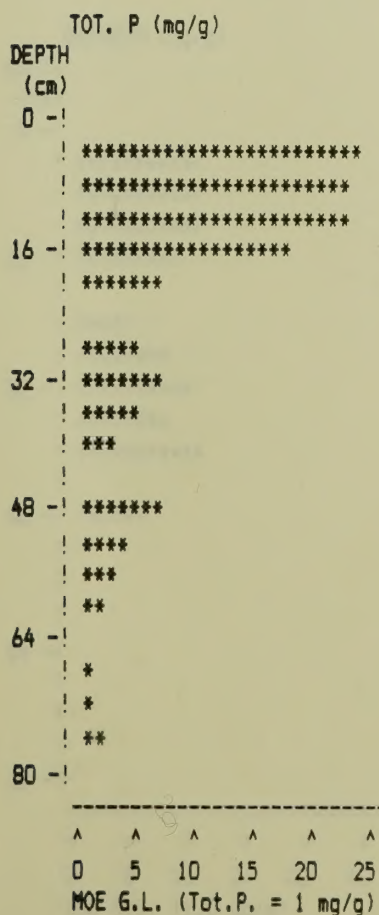
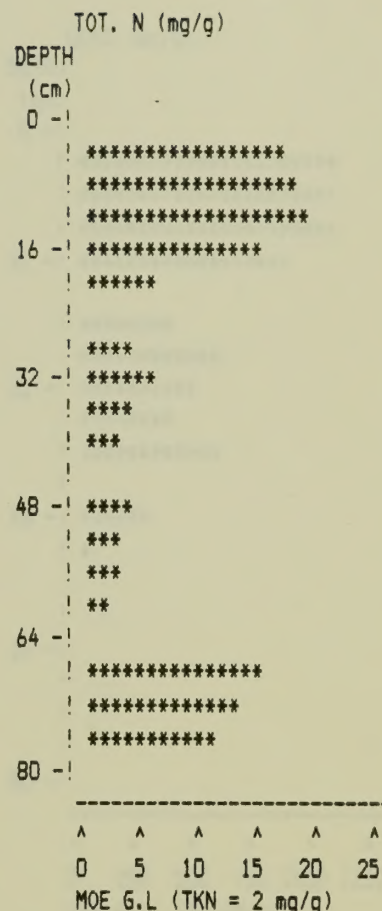
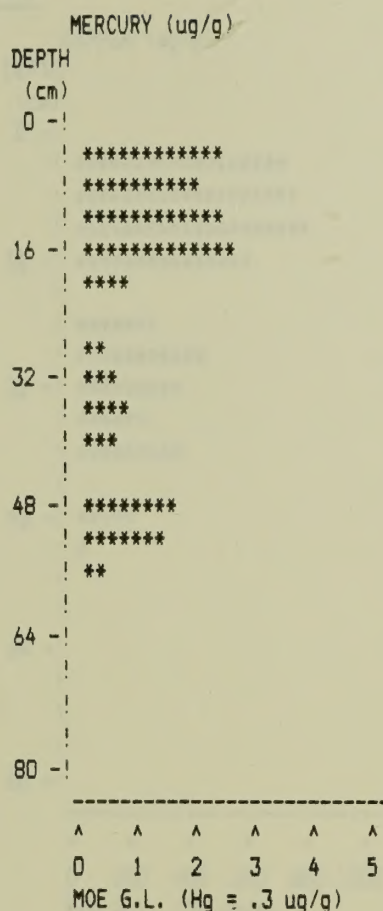
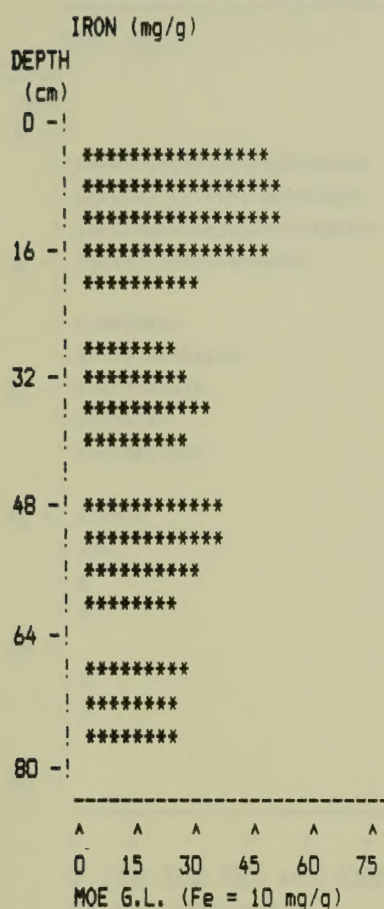


FIGURE 2 (cont'd)

WINDERMERE BASIN - SEDIMENT CORE SAMPLES

(CORE #: 1)



NOTE:

MOE G.L. - Ministry of Environment
guideline for open water
sediment disposal.

FIGURE 3
WINDERMERE BASIN - SEDIMENT CORE SAMPLES

(CORE #: 2)

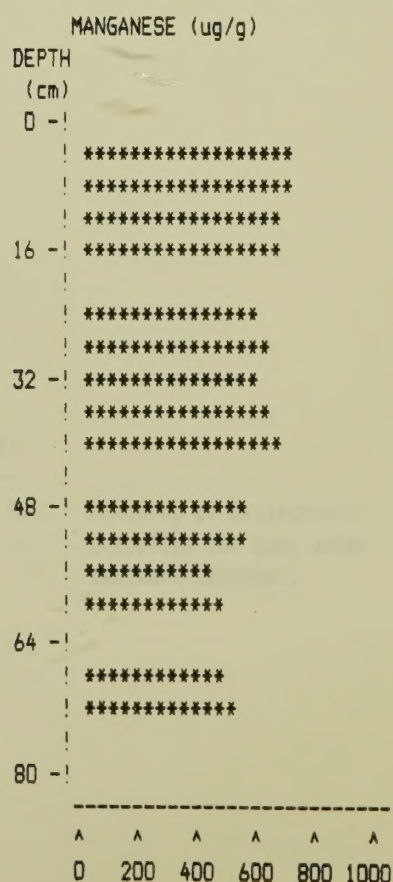
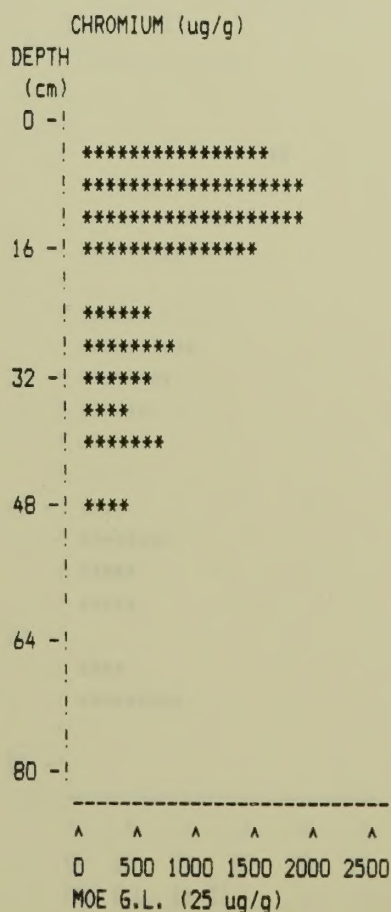
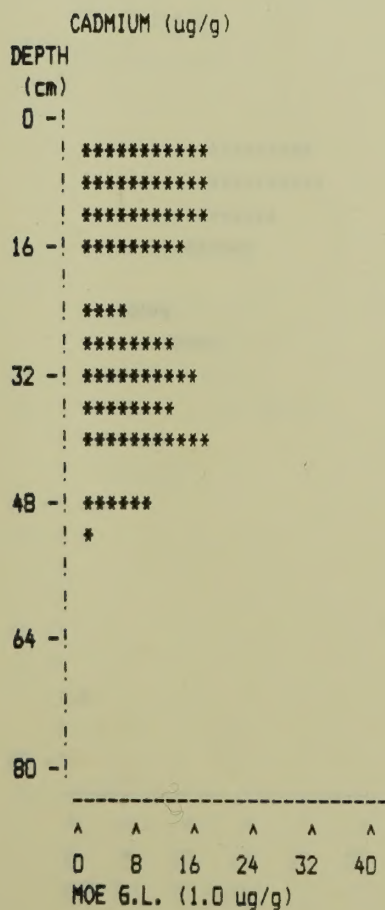
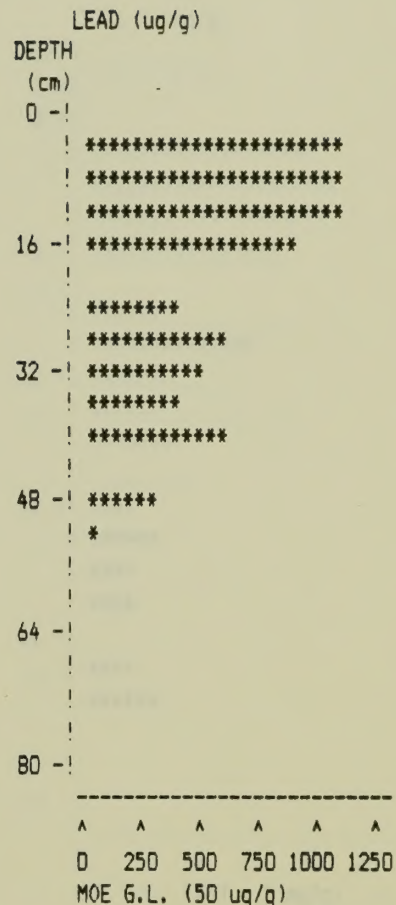
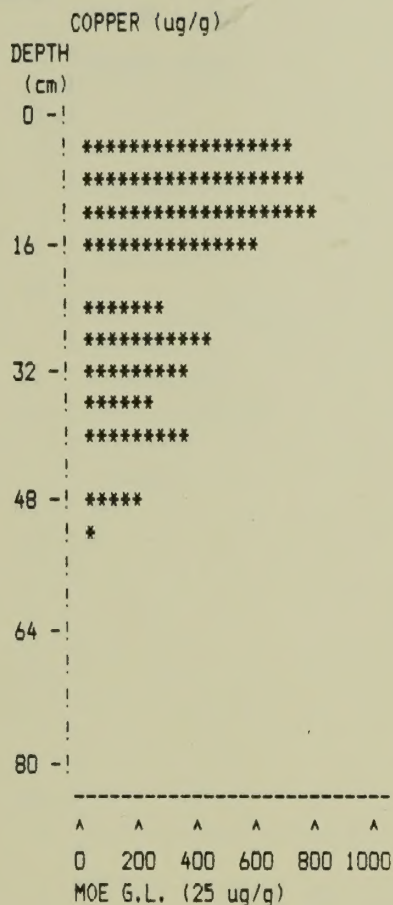
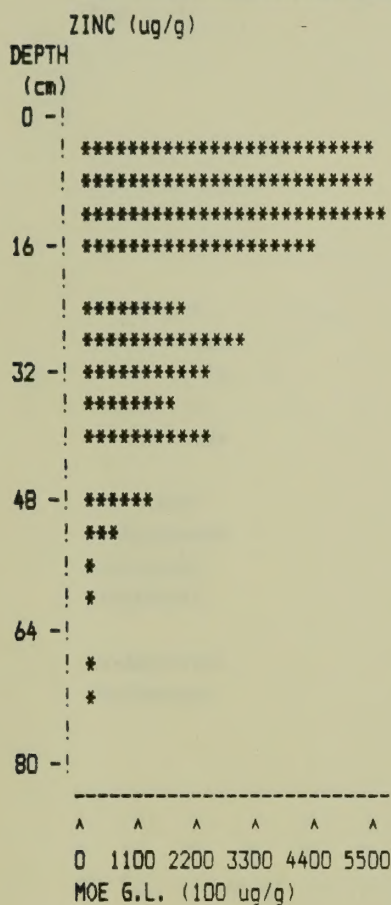
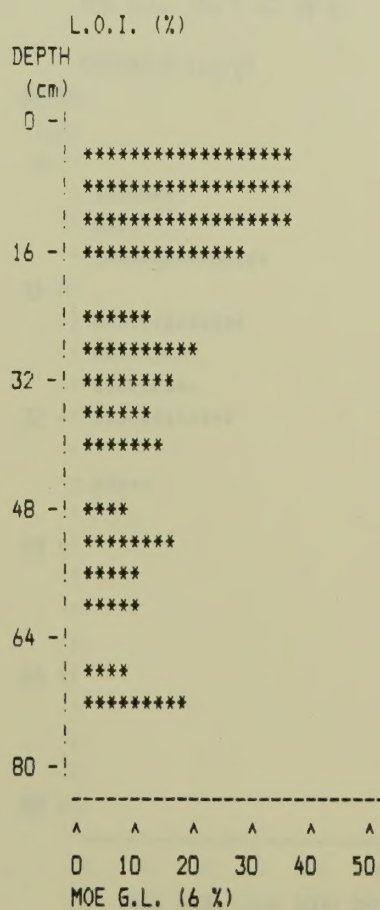
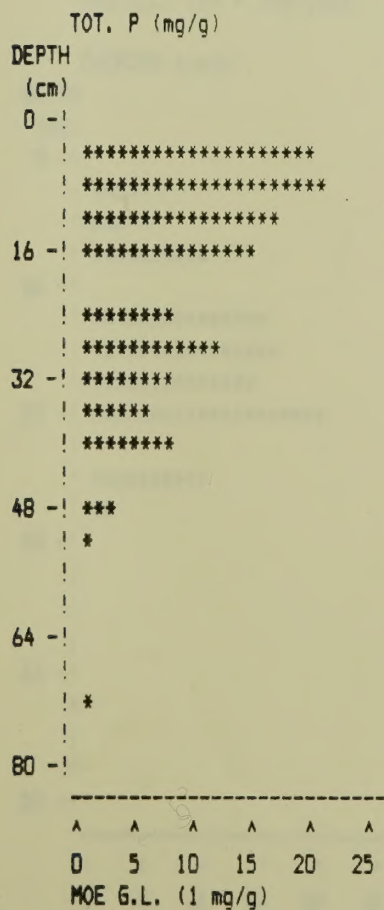
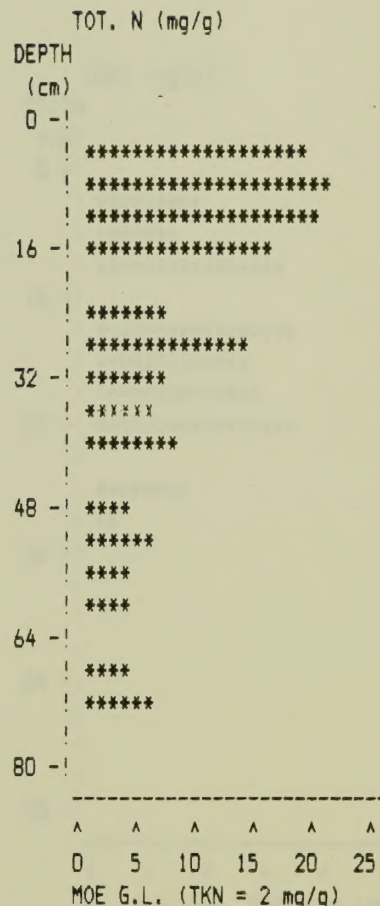
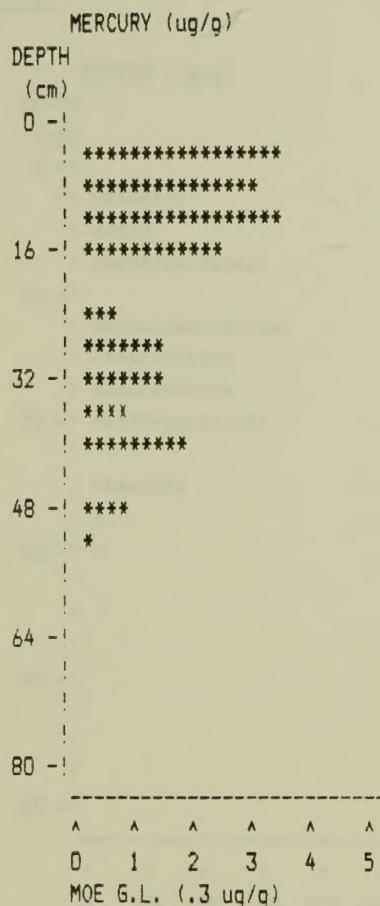
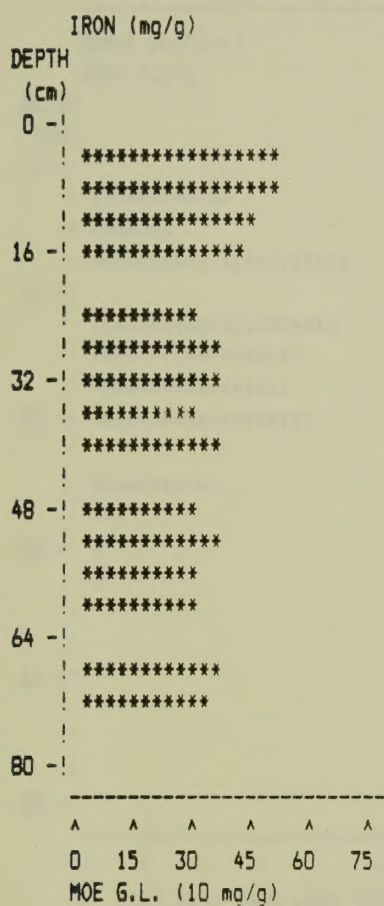


FIGURE 3 (cont'd)
WINDERMERE BASIN - SEDIMENT CORE SAMPLES

(CORE #: 2)



NOTE:

MOE G.L. - Ministry of Environment
guideline for open water
sediment disposal.

FIGURE 4

WINDERMERE BASIN - SEDIMENT CORE SAMPLES

(CORE #: 3)

(west mudflat)

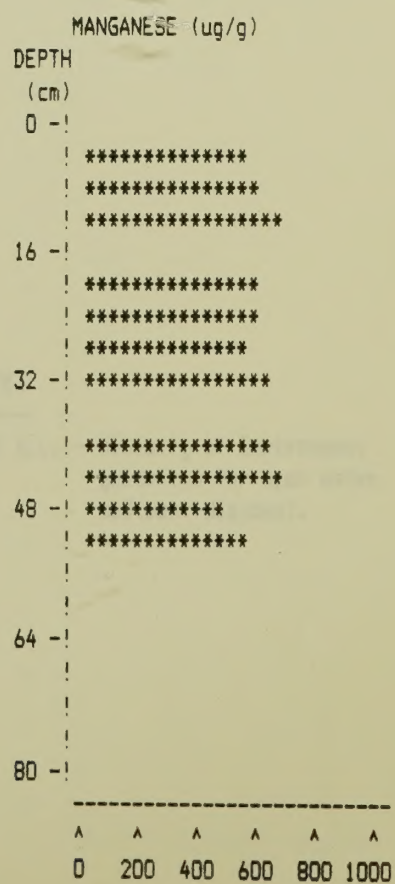
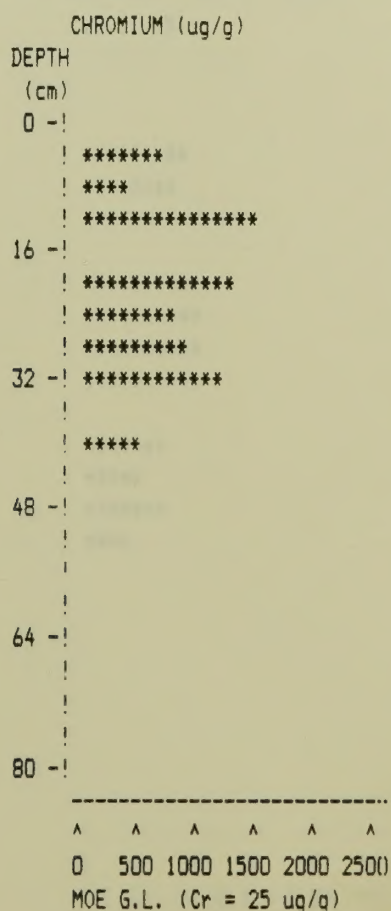
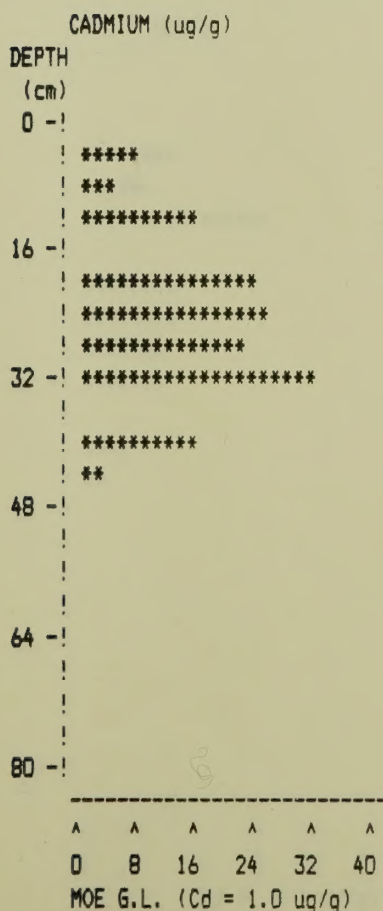
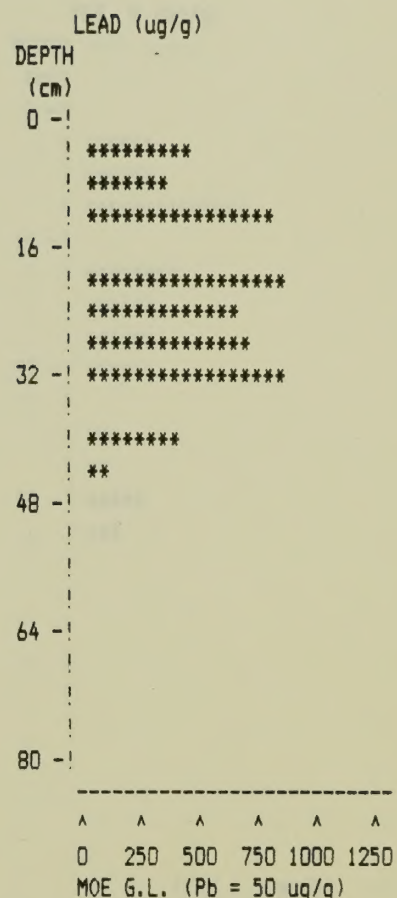
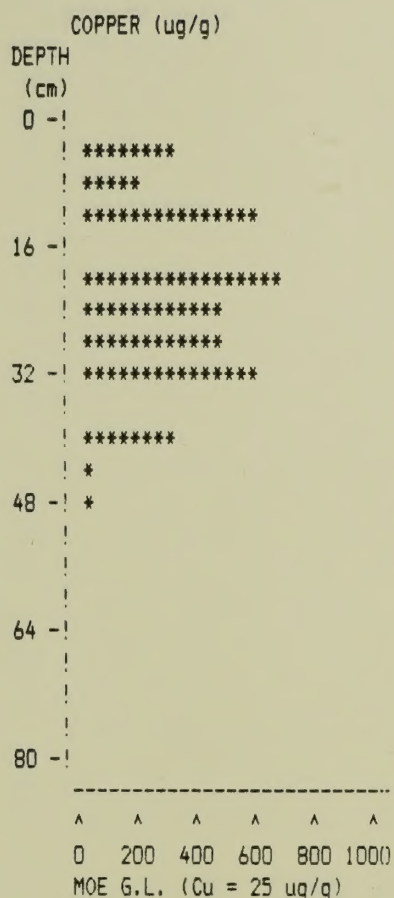
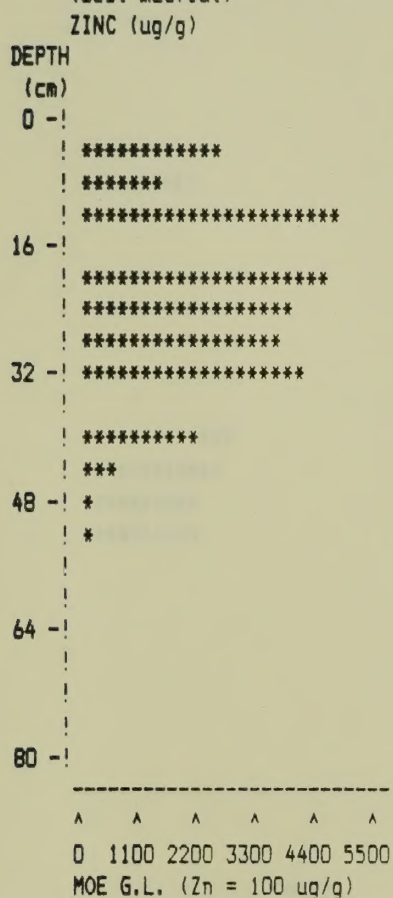


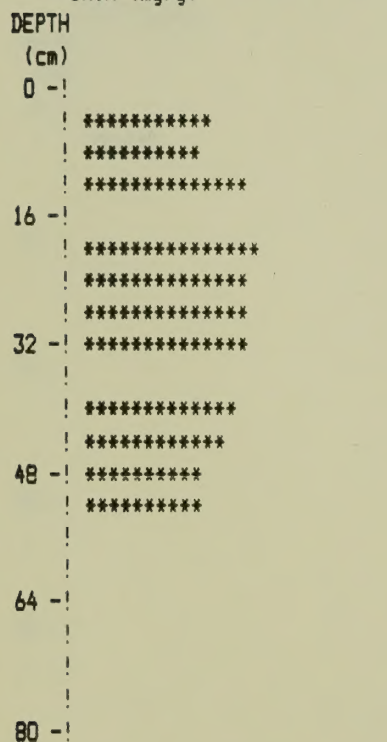
FIGURE 4 (cont'd)

WINDERMERE BASIN - SEDIMENT CORE SAMPLES

(CORE #: 3)

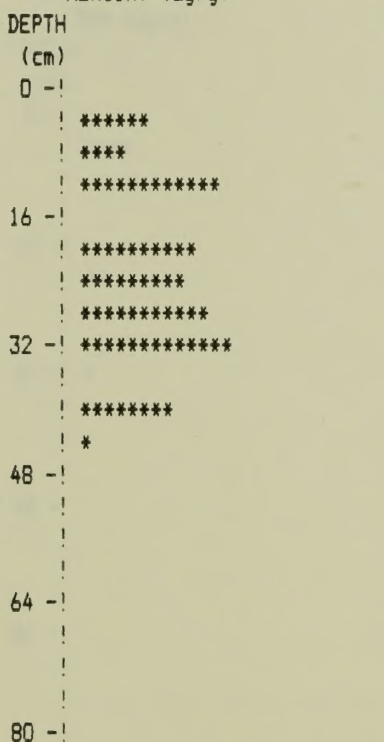
(west mudflat)

IRON (mg/g)



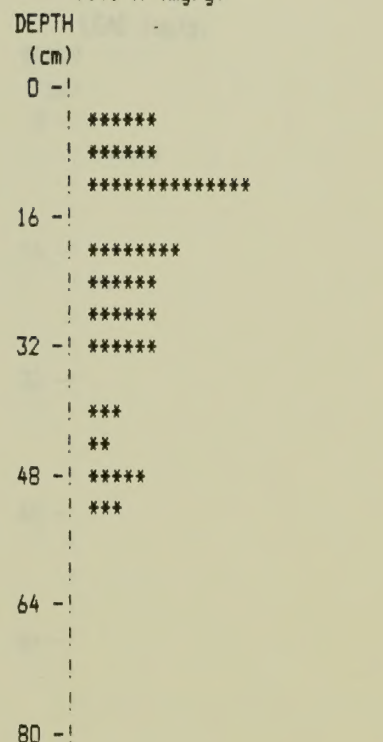
MOE G.L. (Fe = 10 mg/g)

MERCURY (ug/g)



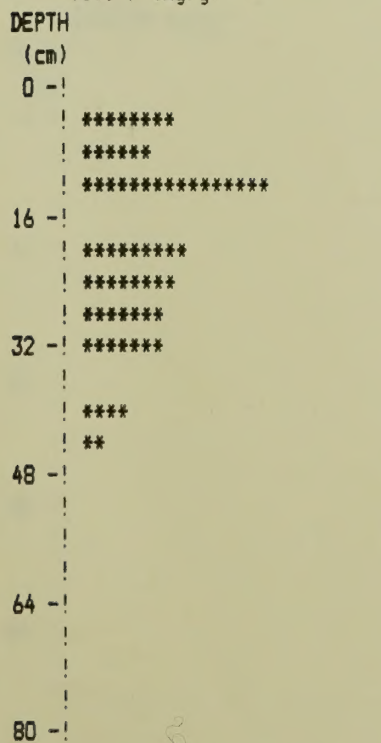
MOE G.L. (Hg = .3 ug/g)

TOT. N (mg/g)



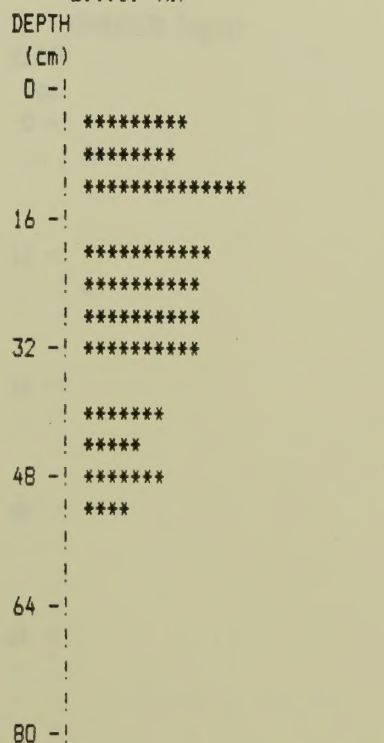
MOE G.L. (TKN = 2 mg/g)

TOT. P (mg/g)



MOE G.L. (Tot.P. = 1 mg/g)

L.O.I. (%)



MOE G.L. (L.O.I = 6 %)

NOTE:

MOE G.L. - Ministry of Environment
guideline for open water
sediment disposal.

FIGURE 5
WINDERMERE BASIN - SEDIMENT CORE SAMPLES

(CORE #: 4)

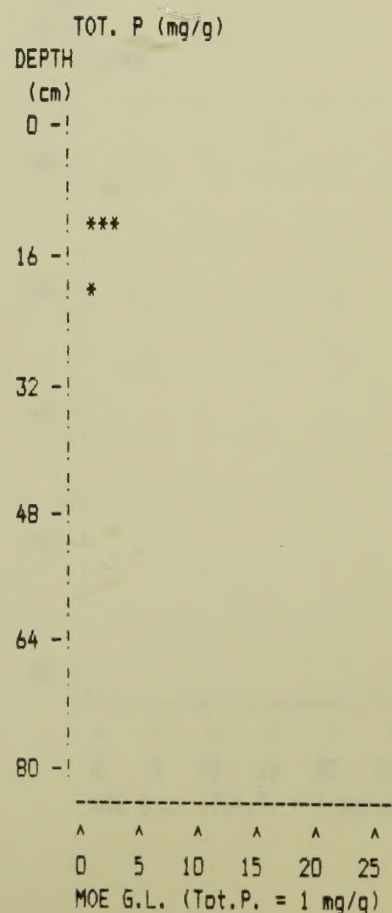
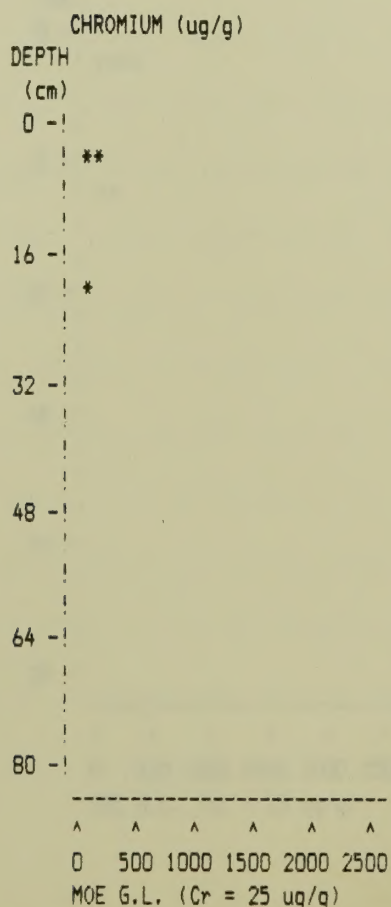
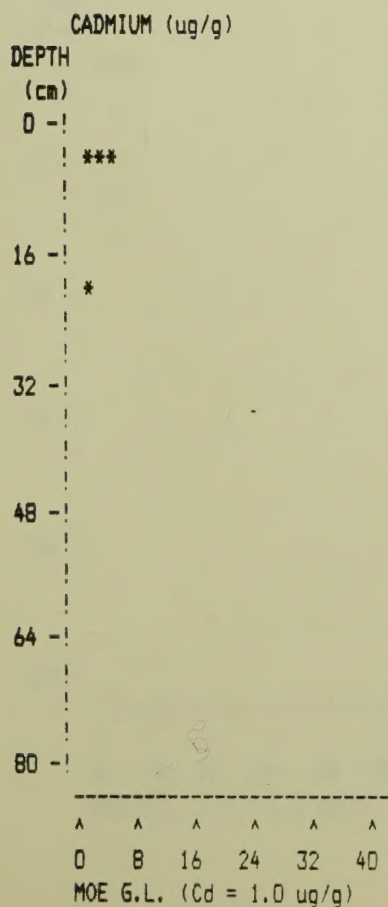
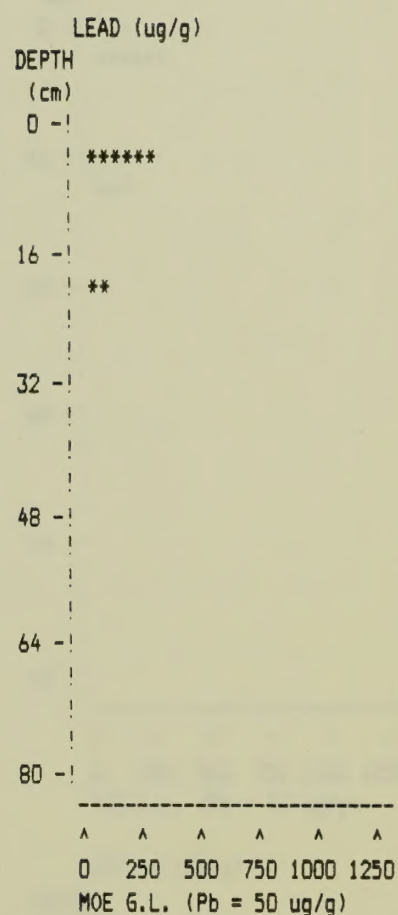
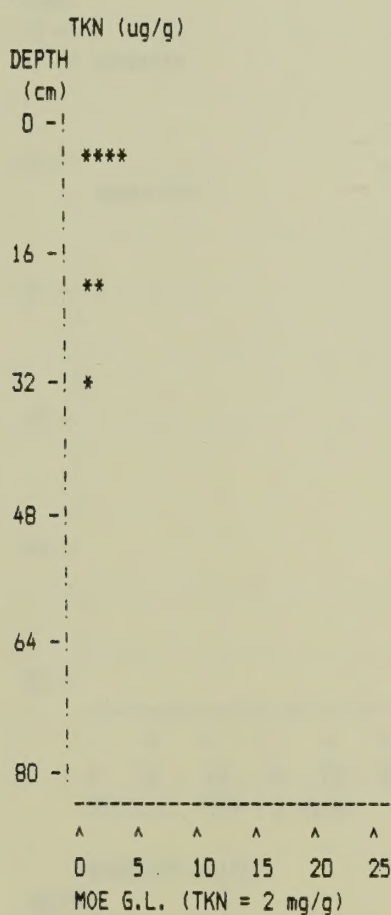
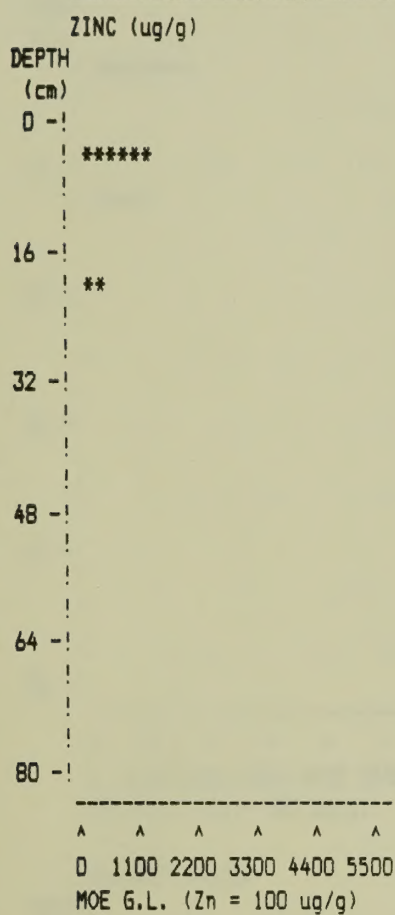
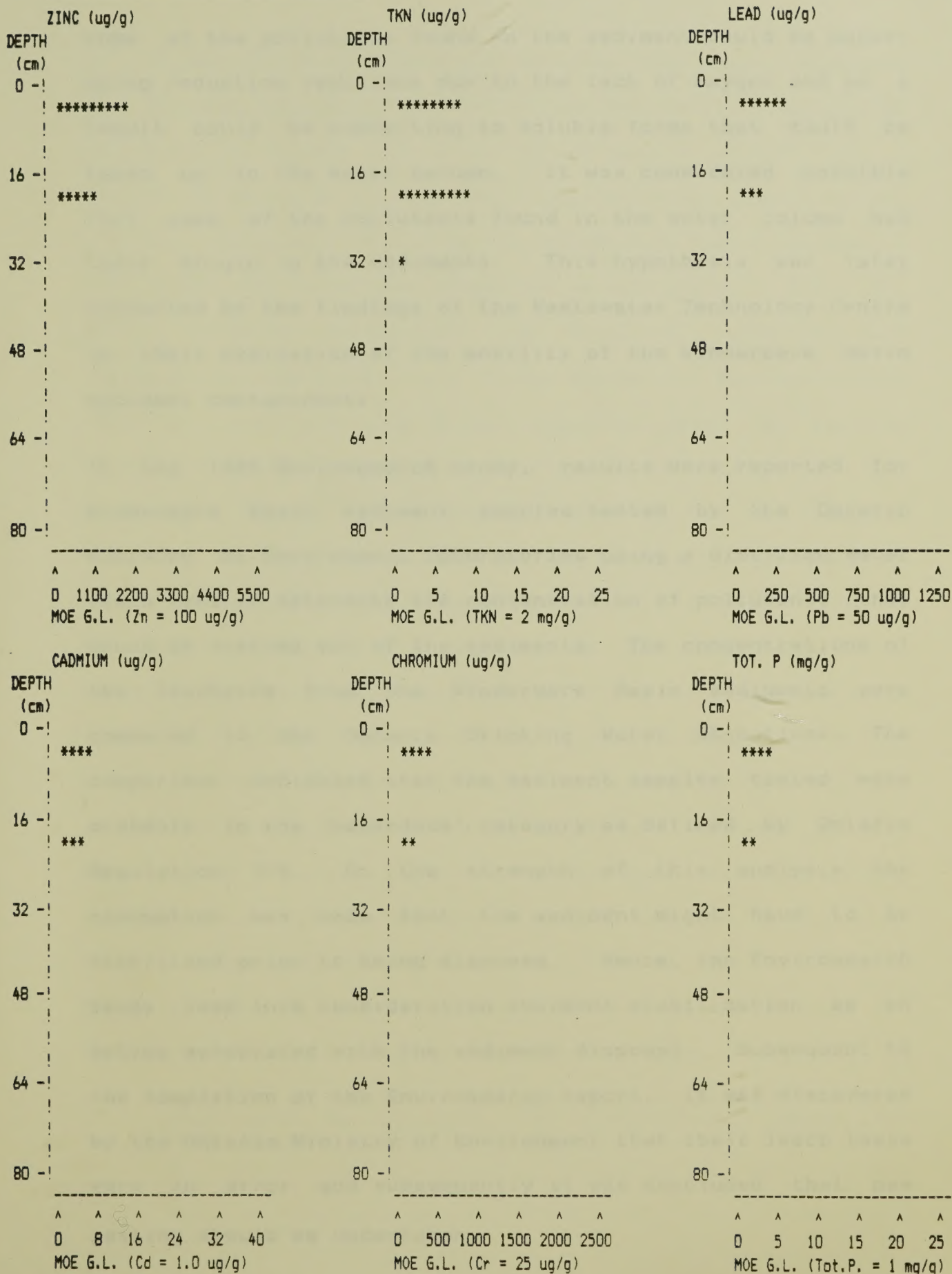


FIGURE 6

WINDERMERE BASIN - SEDIMENT CORE SAMPLES

(CORE #: 5)



some of the pollutants found in the sediment could be undergoing reduction reactions due to the lack of oxygen and as a result could be converting to soluble forms that could be taken up in the water column. It was considered possible that some of the pollutants found in the water column had their origin in the sediments. This hypothesis was later supported by the findings of the Wastewater Technology Centre in their evaluation of the mobility of the Windermere Basin sediment contaminants.

In the 1985 Envirosearch study, results were reported for Windermere Basin sediment samples tested by the Ontario Ministry of Environment laboratories using a distilled water leach test to determine the concentration of pollutants that could be leached out of the sediments. The concentrations of the leachates from the Windermere Basin sediments were compared to the Ontario Drinking Water Objectives. The comparison indicated that the sediment samples tested were probably in the 'hazardous' category as defined by Ontario Regulation 309. On the strength of this analysis the assumption was made that the sediment might have to be stabilized prior to being disposed. Hence, the Envirosearch study took into consideration sediment stabilization as an option associated with the sediment disposal. Subsequent to the completion of the Envirosearch report, it was discovered by the Ontario Ministry of Environment that their leach tests were in error and subsequently it was concluded that new testing should be undertaken.

The Windermere Basin Technical Advisory Committee requested the Residue Management Section of the Wastewater Technology Centre at the Canada Centre for Inland Waters to undertake a series of tests to clarify the situation with respect to the possible hazardous nature of the Windermere Basin sediments (WTC 1986). The study was conducted in two phases. The first phase involved determining the physical, chemical and leachability characteristics of the sediment, by performing chemical analysis and batch leaching tests on samples collected from a heavily contaminated cross-section of the Windermere Basin. The Ontario Ministry of Environment leaching test was performed with the results indicating that the samples were not in the 'hazardous' category. Batch leaching tests were also used and it was determined that there was the potential for mobility of contaminants (especially PCB's) in the sediments particularly when mixed with the overlying water as would occur during scouring resulting from high flow events or during dredging. The second phase involved lysimeter testing that indicated a very low potential for contaminant transport through groundwater from a confined disposal facility back to the Windermere Basin or Hamilton Harbour waters. The conclusion from the Wastewater Technology Centre testing was that:

"removal of sediment from the basin is justifiable and preferable to allowing the sediment to remain in their present condition."

2.3.3 Sediment Mobility

The probability of having sediments scoured relates to the velocity of flow through the basin. Envirosearch (1985) used bottom profile information provided by the Ontario Ministry of Environment to calculate the cross-sectional areas at several locations in the Basin. In turn, these areas were used to calculate average flow velocities through the basin under 5 test conditions. The conditions tested were:

- 1) the November 1983 water level (74.47 metres) with a flow of 3.925 cubic metres per second.
- 2) the average winter season Lake Ontario level (74.36 metres) with a flow of 3.925 cubic metres per second.
- 3) the average summer season Lake Ontario level (74.79 metres) with a flow of 3.925 cubic metres per second.
- 4) the average Lake Ontario level for the month of March (74.6 metres) with a flow of 20.0 cubic metres per second to represent a spring runoff condition.
- 5) the regional storm with Windermere Basin water levels at 76.0 metres and regional storm flow of 380 cubic metres per second assumed to pass through the Basin. The regional storm will represent a flow in excess of the 100 year storm.

The preceding conditions represent various situations that could be expected to occur. The flowthrough velocities for each location and each flow condition were calculated. The areas of the Basin were identified where the flow velocities were slow enough to permit solids to settle during periods of low flow, or fast enough to promote scouring during periods of high flow. To assess the probability of settling or scouring, the velocities were compared to levels generally accepted (MOE 1980) as threshold velocities to promote the

settling or scouring of sediments. Threshold velocities used to determine the probability of sediment being scoured or deposited were:

- grit scours at velocity = 0.9 m/s.
- floc scours at velocity = 0.45 to 0.6 m/s.
- grit settles at velocity = 0.3 m/s.
- organics settle at velocity = 0.12 m/s (0.08 to 0.16)

The Envirosearch study found that under normal and low flow conditions, there are sections of the Basin with flowthrough velocities well below the assumed organic settling velocity of 0.12 metres/second. At the typical (normal) flow that was tested (3.925 cu. m/s.), there were no areas in the basin in which the sediment was likely to be scoured and sediment deposition was found to be likely to occur. Under high flows likely to occur during spring runoff or during major storm events there were sections of the basin that would scour. In particular, the narrow reaches of the basin near the inlet and the area around the mudflat were found to experience some scouring. Envirosearch found the probability of having scouring occur during a major storm event to be quite high.

The 1985 Envirosearch velocity profiles confirmed that the loss of sediment from the basin could be expected. As reported by Envirosearch, some sediment is likely to be scoured each year during periods of high flow. In the event of a major storm, the sediments are light enough and the velocities are high enough to promote the scouring of a significant amount of sediment. The sediments in the basin are quite mobile and prone to movement when subjected to the higher velocities that exist in the Windermere Basin.

2.4 EFFECT OF CONTAMINANTS IN WINDERMERE BASIN

The contaminants in the Windermere Basin have been shown to have an impact on the basin. In addition, studies undertaken by the Ontario Ministry of the Environment discuss the current patterns downstream from the basin. This section discusses the environmental impacts of Windermere Basin on the surrounding area.

2.4.1 Effect on Harbour Water Quality

The Ontario Ministry of Environment (1985) determined the retention time in the Windermere Basin to be 1 to 2 days depending upon the water height in the basin. In turn, the Windermere Basin discharges to the Strathearne Avenue Approach Channel of Hamilton Harbour (approximately 6.2 million cubic metres in volume) which represents in the order of 2.3% of the total Hamilton Harbour volume. Assuming complete dispersion in the Strathearne Avenue Approach Channel, the flows from Redhill Creek and the Woodward Avenue Sewage Treatment Plant would stay in the Channel 21 days. The report (MOE 1985) states that:

"Generally the flow from the channel is directed towards the Burlington Canal, but some of the flow is mixed into the main body of the harbour before flowing through the canal."

This implies a short circuiting of flow toward the Burlington Canal. Pollutants dissolved or suspended in the water column leaving Windermere Basin could be discharged via the

Burlington Canal to the western end of Lake Ontario.

The 1985 Envirosearch report suggests that if the uptake of contaminants from the sediments in the Windermere Basin did not occur, the water quality at the outlet from the basin would be significantly better than the incoming quality from Redhill Creek and the Woodward Avenue Sewage Treatment Plant.

The Wastewater Technology Centre 1986 report, confirmed the ability of contaminants in the sediment to migrate via the water column if the sediments are mixed with the overlying water. The recommendations from the Wastewater Technology Centre favoured the removal of Windermere Basin sediments from their current contact with the overlying water and the placement of the sediments in a confined disposal area.

The Hamilton Harbour Technical Summary and General Management Options (August 1985) pointed to the Woodward Avenue Sewage Treatment Plant as a major source of phosphorus and nitrogen enrichment of the Hamilton Harbour. The report also stated that:

"the harbour is still a prime area of concern in the Great Lakes (IJC 1984). One of the largest factors contributing to the harbour's present state is the level of contamination of the sediments."

The preceding comment would apply to the Windermere Basin sediments as well as the actual harbour sediments.

2.4.2 Effect on Western Lake Ontario Water Quality

The Ontario Ministry of Environment 1986 report 'Impact of Hamilton Harbour on Western Lake Ontario' (Poulton et al.)

discussed the impact of the pollutants in Hamilton Harbour on Lake Ontario water quality. The report states:

"During summer (August) when the harbour is stratified, water chemistry data (nutrients, water clarity, heavy metals) show higher concentrations for parameters such as ammonia, total Kjeldahl nitrogen, total phosphorus, chloride, turbidity, suspended solids, iron and manganese in outflowing waters of the canal, compared to a central harbour sampling location. This suggests the possibility of more direct outflow of industrial and municipal effluents from the southeastern part of the harbour to the canal, without the usual residence period."

The above supports other findings that there is shortcircuiting of discharges from the Windermere Basin to Lake Ontario.

The above report also described findings of field surveys that indicate that the contaminated waters from the harbour do, on occasion, impact the water quality around both the Burlington and Hamilton water intakes in Lake Ontario. This conclusion is as a direct result of water quality measurements taken on two separate occasions. The report stated that:

"Although average water chemistry data at the Hamilton and Burlington Water Treatment Plant (WTP) intakes are not significantly different from those measured at lake background locations, occasional high results were found at the intakes for nutrients (N and P), heavy metals and turbidity. Burlington WTP results assessed in conjunction with plume survey data suggest impingement of the harbour plume on one survey date, while for another date, plume data suggest impingement at the Hamilton WTP intake...".

The above findings demonstrate the potential to have short circuiting of flow from Windermere Basin to Lake Ontario via the Burlington Canal and the potential to have flow from the

Burlington Canal impact the Hamilton and Burlington water intakes.

2.4.3 Effect on Flora and Fauna Including Fish and Waterfowl

Varying opinions exist as to the significance of the contaminants within Windermere Basin with respect to their impact on the population of benthic organisms.

The Ontario Ministry of Environment report The In-Place Pollutants Program - Volume III - Phase 1 Studies (Persaud et al. 1987) stated that:

"At some stations with heavily contaminated sediments such as Windermere Basin and St. Marys River, there appeared to be a toxic influence on biota. Although the sediment provided a suitable substrate, it was devoid of organisms."

A report by Dobos and Weseloh of the Canadian Wildlife Service appears to contradict Persaud et al. in stating that:

"The nutrient rich sediments contain large numbers of benthic invertebrates and support some aquatic submergent vegetation, both important food sources for waterfowl."

Studies undertaken by the Canadian Wildlife Service relating to waterfowl living in the Windermere Basin have indicated the potential for health problems to arise. Following a number of deaths in the wild duck population using Windermere Basin during the fall/winter period of 1985-86, flightless Pekin ducks were placed in the basin. These ducks accumulated PCB residues almost 50 times greater than ducks at other locations (RAP, 1988). These ducks also developed health problems and showed signs of metals poisoning. However,

there was never firm evidence of the source of the lead poisoning. In the fall of 1987, wild ducks resident in the basin became infected with botulism. The conditions in the Windermere Basin were seen to be right for the survival of botulism.

In their report, Historical Review of Hamilton Harbour Fisheries, Holmes and Whillans (1984) indicate that the Windermere Basin historically had "extensive marsh area, excellent spawning, nursery and adult habitat". Under the present conditions they report that the Basin has low rehabilitation potential.

The probability of having fish populations in the Windermere Basin is most likely limited to small populations of Carp. This species is relatively pollution tolerant, however, it is anticipated that during any dredging operation conditions will arise that will kill any fish trapped in the area of the Basin being impacted by the dredging.

2.5 AESTHETICS OF THE WINDERMERE BASIN AREA

Prior to the land reclamation programme instituted in the 1950's, the Windermere Basin was an open water area at the eastern extremity of Hamilton Harbour. The area included a significant area of marshes and related wetlands. As the Windermere Basin was enclosed, sedimentation was accelerated along with the deposition of contaminants including metals and PCB's. At the same time, the surrounding land use became

more industrial. The open nature of the area changed with the last remaining open space being the waters of the Windermere Basin.

This sequence of events can be tracked in the sediment deposits in the basin. Sediment sampling conducted by the Ontario Ministry of Environment as part of the 1982 Windermere Basin Study confirms that the basin supported vegetation as evidenced by the discovery of a root mat located in the sediments at a depth in the order of 65 centimetres below the surface of the existing sediment.

Over time, the Basin has evolved from an open water area in the eastern part of the harbour to a shallow waterbody covered with a layer of grossly contaminated sediments.

Due to the fluctuation in the water level of Lake Ontario and the related changes in the water level of Hamilton Harbour, large deposits of sediment are regularly exposed in the Windermere Basin. These exposed sediments are sterile mudflats that contain a variety of entrained debris that detracts from the aesthetics of the basin. The location of the basin adjacent to the Queen Elizabeth Highway at one of the principal access points to the City of Hamilton makes the basin a high profile setting.

2.6 PUBLIC CONCERNS AND PERCEPTIONS OF WINDERMERE BASIN

Several projects have been initiated to enhance the Hamilton Harbour environment. The Hamilton Waterfront Development Project initiated by the City of Hamilton will convert a former harbour fill site in the southwest portion of the harbour into an island recreational development. Improved industrial and municipal waste treatment and the clean-up of the Desjardin Canal in Dundas have contributed to improved water quality in Hamilton Harbour and Cootes Paradise. The recent effort to develop a Remedial Action Plan (RAP) for the harbour has brought together a cross-section of harbour users to discuss plans for further improvements in the harbour. The RAP report addresses the need to proceed with improvements to Windermere Basin which the public sees as a part of the Harbour. Consequently, considerable public interest has been aroused. Public opinions are now being strongly expressed as to the need for a clean-up of the Windermere Basin. While there is agreement as to the need for a clean-up, there is concern that the clean-up be undertaken with care to avoid further environmental contamination from the polluted sediments.

An article in the June/July 1987 edition of the Canadian Geographic magazine features the efforts underway to clean-up Hamilton Harbour. This article illustrates the interest and timeliness of environmental enhancement projects in the Hamilton environs.

2.7 IMPORTANCE AND URGENCY TO RESOLVE PROBLEM

The Remedial Action Plan for Hamilton Harbour, March 1988, recommends that the clean-up of Windermere Basin "be considered separately from and proceed in advance of the overall Harbour RAP".

The possibility of sediments being scoured from the Windermere Basin and carried through to Hamilton Harbour or Western Lake Ontario could result in environmental degradation. In view of the findings of previous studies that some contaminated sediments are routinely scoured from the Windermere Basin bottom deposits and discharged to the Strathearne Avenue Approach Channel, it follows that a definite risk exists that some environmental degradation can be expected to occur regularly in Hamilton Harbour as a result of the scouring of sediment from the Windermere Basin.

Under existing conditions it is possible to have a series of events involving a major storm that could result in polluted sediments being flushed from the Windermere Basin and carried into Hamilton Harbour.

In addition to the threats to water quality in the harbour, there is the hazard that is posed to waterfowl that use the Windermere Basin. Several hundred waterfowl deaths have recently occurred in the populations of waterfowl that use the Windermere Basin.

Summary comments from the Ontario Ministry of Environment, 1985 report - Hamilton Harbour Technical Summary and General Management Options identify the problem. The report states that:

"One of the largest factors contributing to the harbour's present state is the level of contaminants of the sediments. Present inputs from the point sources continue to provide an environmental stress which cannot be assimilated by the harbour ecosystem."

Although the report addresses the overall Hamilton Harbour situation, the findings are also pertinent to Windermere Basin. The report identified a series of management options for the harbour which specifically included the "dredging of Windermere Basin".

It is not possible to predict when or if the storm conditions will arise that could scour sediments from the Windermere Basin and cause serious environmental problems. This uncertainty adds to the element of urgency to undertake a clean-up of the Windermere Basin in order to reduce the existing environmental risk associated with the 'in situ' contaminated sediments.

The most important consideration is that the volume of Windermere Basin is now reduced to the degree that there is little room remaining to trap sediment and pollutants being discharged to the basin. As a consequence, sediment discharging to the basin will either pass through to Hamilton Harbour, or displace contaminated sediment already in the basin which in turn will pass into the harbour. The situation will not improve with time.

The existing information supports a conclusion that the clean-up of Windermere Basin would definitely benefit the basin and the adjoining waters of Hamilton Harbour.

The conclusion of the Windermere Basin Technical Advisory Committee as to the need to clean-up the Windermere Basin is supported by the findings of the Wastewater Technology Centre investigations, by the 1985 Envirosearch study, by the Remedial Action Plan investigations and by the Ontario Ministry of Environment studies.

4.1 REMEDIAL ACTION PLAN INVESTIGATIONS

The disposal techniques that were considered in detail for the remedial action plan are listed below. The techniques are listed in order of increasing cost and complexity.

- 1 - On-site treatment and disposal of sludge and other solids.
- 2 - Dewatering of sludge and the transportation of the dewatered sludge to a landfill.
- 3 - Dewatering and incineration of the sludge at the Wastewater Treatment Plant. The organic content of the sludge would be destroyed and the inorganic residue would be disposed of in a landfill.

The following section further describes these techniques.

3.0 ALTERNATIVES CONSIDERED TO SOLVE WINDERMERE PROBLEM

The report prepared by Envirosearch Limited (1985) for the Windermere Basin Technical Advisory Committee considered the following alternatives for the clean-up of Windermere Basin:

- do nothing
- complete dredging
- partial dredging
- raise water level with dam
- create marsh
- channelize and fill
- combination of above.

The alternatives, which involve either leaving the contaminated sediment in Windermere Basin in some form, dredging the sediments and placing dewatered sediment in a landfill or incinerating dewatered sediment at the Woodward Avenue Sewage Treatment Plant are discussed in detail below. Various sediment disposal alternatives that were considered for each of the clean-up alternatives are presented first.

3.1 SEDIMENT DISPOSAL TECHNIQUES

The disposal techniques that were considered to warrant further consideration for the Windermere Basin sediments included:

- 1 - On-site disposal in which a containment area would be created within a portion of Windermere Basin.
- 2 - Dewatering of sediments and the transporting of the dewatered sediments to a landfill.
- 3 - Dewatering and incineration of the sediments at the Woodward Avenue Sewage Treatment Plant. The organic sediments would be digested and incinerated. Inorganic grit would be separated and disposed with other grit from the sewage treatment process.

The following sections further discuss these techniques.

3.1.1 On-Site Disposal

The Envirosearch report (1985) considered the most likely alternative for a disposal site for contaminated sediments from Windermere Basin to be the creation of a dyked disposal area within a portion of the Basin. It was accepted that the reduction of surface area in the Basin to create a containment area could reduce the potential surface oxygen transfer capacity. However, the related reduction in sediment oxygen demand could offset the need for the additional surface re-aeration capacity. The potential benefit from removing the contaminated sediment in the basin from the 'Redhill Creek - Hamilton Harbour - Lake Ontario' environment was seen to offset the loss of re-aeration capacity potential. The development of a containment area within the basin was seen to be an environmentally acceptable tradeoff in order to isolate the contaminated material from the aquatic environment.

The Envirosearch report (1985) considered the possible need for chemical stabilization to treat the sediments so that the contaminants would be bound up in an impermeable soil cement. The Ontario Ministry of Environment data that had previously indicated that the Windermere Basin sediments were probably hazardous had generated concern that contaminants might be leached from the containment area unless the sediment was chemically fixed as proposed by Envirosearch.

One drawback that was identified with the chemical

stabilization of contaminated sediments was that the end volume of the material to be disposed would be approximately doubled. Hence, a significantly greater capacity might be required in the containment area. The available information suggested that the nature of the stabilized sediment was such that, it would not necessarily require that a greater water area be taken from the basin to dispose of the sediments that would have to be removed. It was considered that the stabilized sediment might be used to create above ground screening berms similar to the berms used around quarry operations. This could facilitate the development of a visual screen that, in association with a landscaping programme, could hide much of the National Slag and Stelco industrial operations. The cost of stabilizing the sediment and creating the berm disposal areas were high compared to a conventional confined disposal area. As a result of the higher cost, and in view of the suitability of the basin sediments for conventional confined disposal, the sediment stabilization option was rejected.

The prefeasibility design concept proposed by Mar-land (1984) pointed to the possibility of numerous configurations that could be developed for creating containment areas to dispose of contaminated sediment from Windermere Basin. Mar-land suggested that conventionally designed dredged spoil containment areas could be utilized such that 50% of the Basin area could be maintained in open water (approximately 20 hectares).

The Envirosearch report (1985) favoured the development of a containment area within the Basin in that such an approach would have a much higher probability of success than the development of other disposal alternatives. Cost estimates for the development of a containment area involving the construction of berms and the dredging and disposal of the dredge spoils behind the berms were estimated to range from \$3.75 to \$7.0 million depending upon whether or not dewatering and chemical stabilization of the sediment was utilized.

3.1.2 Dewater Sediment and Transport to a Landfill

The Envirosearch report (1985) presented one scenario whereby the sediment would be removed from Windermere Basin, dewatered and the solids portion of the material hauled to a landfill. The report suggested the use of 2-metre belt filters similar to the type used to dewater sludge in sewage treatment facilities. It was projected that the 2-metre filters could process approximately 1,800 kilograms of dry solids per hour per filter.

The quantity of contaminated sediment was estimated to be equivalent to 80,000 tonnes of dry solids. Assuming that the sediment dewatering operation would be undertaken in association with a landfill disposal alternative, the equipment would most likely be located adjacent to Windermere Basin. The report projected the need for 4 filter units working two

shifts per day from May to October over a period of 7 years to dewater the sediment. Dewatered sediment would then have to be hauled to a landfill.

Subsequent Wastewater Technology Centre testing indicated that the dewatered sediment is non-hazardous. Therefore, it should be suitable to be landfilled at Taro Properties Inc. in Hamilton or Walker Brothers Quarries Ltd. in Niagara. The Hamilton-Wentworth Glanbrook landfill is restricted in the type of materials that can be landfilled. Alternatively, sediment could be disposed at approved landfills in New York State or possibly Sarnia. The latter sites were originally considered before it was discovered that the Ontario 'hazardous' test results were in error.

The cost of dewatering sediment was estimated to be approximately \$80.00/tonne of dry solids. At 80,000 tonnes of dry solids, the dewatering cost would be in the order of \$6.4 million.

In addition, the cost of trucking would have to be included to move the dewatered sediment to an appropriate landfill. At a haulage rate of \$2.50 per tonne per 10 kilometres, the cost to move 250,000 tonnes of dewatered sediment (ie. 80,000 tonnes of dry solids if only dewatered to 30% moisture content) would be in the order of \$63,000 (\$1985) per kilometre of haulage distance.

Haulage costs for disposal sites at various locations were estimated (\$1985) as follows:

- Taro (32 km) \$ 2.0 million
- Sarnia (225 km) \$14.2 million
- Niagara Falls, N.Y. (90 km) \$ 5.7 million

The actual landfill cost which must also be included could be in the order of \$50.00 per tonne, which at 250,000 tonnes would cost \$12.5 million. The cost of dredging would be in the order of \$2.0 million. The total estimated cost of dredging, dewatering and trucking to landfill, could be in the order of \$22.9 to \$35.1 million. In addition to the high cost factors, there was also the consideration of the high volume of truck traffic that would be generated in hauling the dewatered sediment to a landfill. This traffic would create an environmental hazard should any material be spilled, plus there would be safety risks created for people using the truck haul roads.

3.1.3 Dewatering and Incineration of Sediments at the Woodward Avenue Sewage Treatment Plant

Sediment removed from Windermere Basin could be pumped to the Woodward Avenue Sewage Treatment Plant and processed through the plant. The inorganic grit solids would be separated at the pretreatment facilities and the organics solids would be separated with the other sewage solids and digested. The digested sludge would then be dewatered and incinerated. The ash would be disposed with the ash from the sewage solids.

One possible problem is the high levels of phosphorus in the Windermere Basin sediment. Currently, the Woodward Avenue Sewage Treatment Plant produces an effluent with over 1 mg/L

of phosphorus. Efforts are underway to reduce the phosphorus in the effluent to acceptable levels. If the current efforts are not successful, the plant may have to be upgraded with additional equipment. If the Windermere sediment is treated at the Sewage Treatment Plant the high levels of phosphorus in the sediment would probably cause the phosphorus levels in the effluent to rise such that there could be a potential violation of the 1 mg/L International Joint Commission requirement which, in turn, could place the plant in violation of the Canada-U.S. water quality agreement.

There is space at the Woodward Avenue Sewage Treatment Plant to install 4 belt filters similar to the units discussed in section 3.1.2. Making the assumption that the filters could be operated in the sewage treatment plant with limited down time for maintenance, the dewatering of the sediment could take as little as 3 years. However, due to additional constraints imposed by the dredging operation the time required would more likely be 4 to 5 years.

The existing incineration facilities at the Sewage Treatment Plant can process the additional sediment volume that would be produced by four extra filters.

The incremental cost of dewatering and incinerating the sediment at the Woodward Avenue Sewage Treatment Plant was calculated to be \$100.00 per tonne of dry solids. To incinerate 80,000 tonnes the cost would be \$8.0 million (\$1985). If a significant portion of the Windermere sediment

is categorized as grit, then a larger percentage would be removed at the pretreatment phase. This would increase the pretreatment cost but reduce the incineration cost. Depending upon the percentage of the sediment that is grit, there could be some savings in the estimated \$8.0 million incineration cost.

There would also be the cost of dredging to be included as per the section 3.1.2 estimate of \$2.0 million.

The total estimated cost of dredging, dewatering and incinerating the sediment at the Woodward Avenue Sewage Treatment Plant is \$10.0 million (\$1985).

3.2 WINDERMERE BASIN CLEANUP ALTERNATIVES

Each of the alternatives indicated in section 3.0 were studied with consideration given to the positive and negative benefits that would accrue from implementing the alternative.

Options that involve the movement of sediment dictate that consideration be given to both the prevention of undue contamination of the aquatic environment during the removal process and the disposal of the sediment in some environmentally acceptable fashion. Each alternative that has been considered is discussed below with the findings of the various studies being presented. This is the background upon which the Windermere Basin Technical Advisory Committee based its conclusions.

3.2.1 Do Nothing

Sedimentation has occurred in Windermere Basin such that for extended periods of each year, large areas of the Basin are exposed mudflats. At other times of the year, when water levels in Lake Ontario and Hamilton Harbour rise, the depth of water in the Basin covers the mudflats, leaving the impression of an open waterbody. If the 'do nothing' option is accepted, this cycle will continue, with the mudflat area increasing with time until a progressively larger area of the basin is exposed at low water levels.

The long term implications of a 'do nothing' option are unknown. Presumably, if the option is pursued indefinitely, it is possible that the mudflats could eventually support cat-tails or some other species of aquatic plant and the basin could evolve toward a marsh environment. In view of the very light density of the sediments in the mudflats and the significant fluctuations in the water levels, it is possible that aquatic plants might not become established and as a consequence, the natural conversion to marsh could take considerable time to occur. The absence of growth at this time could also be indicative of toxic conditions that would continue to impede aquatic plant development.

a) Environmental Concerns

The most significant environmental concern associated with the 'do nothing' option is that portions of the highly contaminated sediments in the Windermere Basin are being scoured each year by high flows such as those occurring

during spring runoff or major storm events. The quantity of contaminated sediment that is scoured each year under these conditions is limited, however, a significant portion of the sediments in the Basin could be scoured by a major storm event such as a 'Regional Storm'. If this were to occur, contaminated sediments that are currently in the basin could be flushed into Hamilton Harbour and possibly to Lake Ontario where they could have an impact on water quality or fish and aquatic life. There is no way to predict when such a severe storm might occur.

Another environmental concern is that wildlife, including the waterfowl that now frequent Windermere Basin are being exposed to levels of pollutants that could affect the health of these species. Since the 1985 Envirosearch report, incidents have occurred whereby the resident duck population has been poisoned, presumably by contaminants originating in the Windermere Basin sediments.

The continued presence of the contaminated sediments in Windermere Basin will also mean that there is the ongoing risk of uptake of various metals and contaminants in the water column. The Envirosearch analysis of water quality data for the Basin and the Wastewater Technology Centre (1986) report both support this hypothesis.

The information available at this time supports the conclusion that there is considerable environmental risk associated with doing nothing and leaving the Windermere

Basin sediments in situ.

b) Environmental Benefits

The long term environmental benefits from Windermere Basin will continue to decline if the contaminated sediments in the basin are not isolated from the environment. In its present form, the basin affords some benefit by providing a limited assimilation of the oxygen demanding substances associated with the treated effluent being discharged from the Woodward Avenue Sewage Treatment Plant. If nothing is done, the basin will continue to fill with sediment until it is effectively filled in and channelized. The majority of the existing limited assimilation benefit will eventually disappear. In its present condition there is some environmental benefit accruing from Windermere Basin although it is definitely limited and declining with time.

c) Aesthetic Considerations

Assuming the continuation of a 'do nothing' option, there is little aesthetic value that can be credited to the Windermere Basin.

During the summer months, when water levels are high, at first glance the Basin looks like an open water body, however, a closer look identifies debris around the shoreline and in some areas tree stumps, rubber tires and other refuse protruding from the water.

At times of the year when Lake Ontario water levels are low,

the mudflats are exposed and the basin has even less aesthetic appeal.

d) Costs

The 'do nothing' option requires no expenditure of dollars to be incurred at this point in time. Assuming that an environmental contingency does not occur and the environmental hazards discussed previously can be tolerated, the 'do nothing' option will continue to have no dollar cost. However, if sediment continues to accumulate in the basin the eventual correction of the problem will cost more than if the problem is addressed now by removing the contaminated sediments from the Windermere Basin. From the viewpoint of downstream navigation, doing nothing to clean-up Windermere could result in additional sediment being transported downstream with a resultant cost occurring for the removal of this sediments from the Strathearne Avenue approach channel.

e) Socio-Political Considerations

There is an increasing interest on behalf of Hamilton area residents to see something done to improve the appearance of Windermere Basin. The public disapproves of the image of the Hamilton area that is created by Windermere Basin in its present state. Current moves to promote a 'Beautify the Harbour Concept' indicate an interest on behalf of the population to see the correction of conditions such as those in Windermere Basin.

The local, regional, provincial and federal levels of govern-

ment and their associated agencies have all expressed a desire to see a Windermere Basin clean-up occur. The various levels of government have also taken the step of committing funds to the present Windermere Basin clean-up project.

The interest expressed by residents and the actions taken by the various government agencies serve as a strong statement against a 'do nothing' approach to the Windermere Basin.

3.2.2 Complete Dredging and Off-Site Disposal or Incineration

'Complete Dredging' involves the removal of sediments from the bottom of the basin along with some form of sediment disposal such that the surface area of the basin is not reduced. This alternative would maintain the maximum water surface within the basin, remove the contaminated sediments, provide sediment trap capacity and increase the assimilation capacity of the Basin.

The major drawback with the alternative is that the sediments removed from the Basin would require some form of off-site confined disposal facility. In view of the level of metals and PCB contamination in the sediments, any disposal facility would likely be opposed by neighbours. Approval for such a disposal facility would be difficult to obtain. Alternatively, any treatment such as incineration would have to be capable of destroying or containing compounds such as PCB's or heavy metals.

a) Environmental Concerns

The major concern associated with this alternative is the loss of contaminants to the aquatic environment during the dredging and disposal processes. This could occur both as a result of sediment losses from around the dredge and from the discharge of contaminated decant water from the sediment treatment area.

There is also the concern that wildlife could be exposed to pollutants in the sediment disposal area prior to final capping.

b) Environmental Benefits

The hydraulics of flow through Windermere Basin would be improved. This would provide an opportunity to create a sediment trap in the basin that could reduce the need for maintenance dredging further downstream in the approach channel to the Strathearne slip and in the areas adjacent to the East Port pier facilities.

X The removal of the contaminated sediments would reduce the risk of pollutant resuspension into the water column, thereby reducing the risk of discharging these materials to Hamilton Harbour or possibly to Lake Ontario.

The assimilative capacity of the Basin would be increased if dredging were undertaken and the sediments having a high sediment oxygen demand were removed. This could provide some additional benefit in the form of post discharge aeration and suspended solids removal for the effluent from the Woodward

Avenue Sewage Treatment Plant prior to its discharge to Hamilton Harbour.

c) Aesthetic Considerations

The removal of the sediments from the Basin could eliminate the exposure of mudflats during periods of low water levels. This would maintain the 'waterbody' appearance of the Basin and provide an enhanced aesthetic appeal.

d) Costs

The 'complete dredging' option would require the expenditure of a significant sum of money both for the dredging portion of the work and for the disposal of the contaminated sediments. Depending upon where the sediments were to be disposed and what process was to be used, the sediment disposal aspect of the project could become the largest expenditure.

The complete dredging of Windermere Basin would remove the contaminated sediments from the Basin. Even though these sediments have been tested and found to be non-hazardous, it would still be difficult to establish a suitable off-site disposal area. As discussed previously, there are existing private landfills including the Taro Properties Inc. landfill north of Hamilton and the Walker Bros. Quarries Ltd. landfill in Niagara that could take the sediment. However, the owners might not wish to accept the large volumes involved in this clean-up. The major problem relates to the cost of dewatering the sediment and both the logistics and cost of moving such a

large quantity of material by trucks. Another problem with this option is the high cost of the landfilling fees. The rate at which sediment can be dewatered could force the project to be spread over as many as seven years. As discussed previously, the cost of dredging, dewatering sediment, trucking to a landfill and tipping sediment is estimated to be in the order of \$22.9 to \$35.1 million (\$1985).

Assuming that the dredging of the Basin could be undertaken such that the sediment could be treated at the Woodward Avenue Sewage Treatment Plant, the organic portion of the sediments could then be incinerated. This alternative would substantially reduce the cost of trucking and landfill fees, however, energy costs for the incineration process would have to be added to dewatering costs. As discussed previously, a major problem would be that the project could take several years to complete because of limitations posed by the dewatering process. The cost of dewatering and incinerating the sediment at the Woodward Avenue Sewage Treatment Plant has been estimated to be in the order of \$10.0 million (\$1985).

e) Socio-Political Considerations

The 'complete dredging' option complements the expressed desires to clean up the Windermere Basin. However, if the disposal of sediments involves off-site trucking, processing or landfilling, it is anticipated that the project could

become embroiled in a "Not in My Back Yard" syndrome. The solution to the Windermere problem could then result in the creation of a second and possibly more volatile public concern with respect to the development of an acceptable disposal facility.

3.2.3 Partial Dredging and Fill

Partial Dredging and Fill involves the removal of sediments from the bottom of a portion of the basin with a sediment disposal area created in adjacent portions of the basin. The sediment disposal area could be sized to permit the disposal of all of the dredged sediment with some additional capacity for future maintenance dredging. The disposal area would be designed to prevent contaminants in the sediment being leached from the confinement area.

a) Environmental Concerns

The major concern associated with this alternative is the loss of contaminants to the aquatic environment during the actual dredging and disposal processes. This could occur both as a result of sediment losses from around the dredge and from the discharge of contaminated decant water from the sediment disposal area.

The dredged material will be placed in the sediment disposal area to an elevation of approximately 75.9 metres before settling takes place. This is 1.0 metres above the summer high water level. The dredged material will be placed in the disposal area during the fall of 1988 and left to dewater

until the winter of 1990 when it will be capped while there is frost in the surface layers of the material. During this period the disposal area will be exposed to the atmosphere prior to final capping. There could be a hazard for wildlife including waterfowl during the period following the dredging activities and prior to the capping operation.

b) Environmental Benefits

The hydraulics of flow through Windermere Basin would be improved. This would provide an opportunity to create a sediment trap in the basin that could reduce the need for maintenance dredging further downstream in the approach channel to the Strathearne slip and in the areas adjacent to the East Port pier facilities.

The removal of the contaminated sediments would reduce the risk of pollutant resuspension into the water column, thereby reducing the risk of discharging these materials to Hamilton Harbour or possibly to Lake Ontario.

The removal of contaminated sediments will reduce the sediment oxygen demand in the dredged area. The assimilative capacity of the open water area will be increased. Since the area of the basin that will be filled for sediment disposal is routinely exposed as a mudflat, the overall assimilative capacity of the Basin should not decrease.

This alternative involves the development of an on site solution to the problem which will eliminate the need for

large volume trucking of materials. This will reduce the level of nuisance for individuals in the general vicinity of the truck haul routes, plus eliminate the risk of in transit accidents involving the material being trucked to the disposal site.

c) Aesthetic Considerations

The size of the basin will be reduced and consequently there will be less open water surface, however, the major problem of exposed mudflats will be resolved. The shoreline will be reconstructed and improved with landscaping. There should be a net aesthetic improvement in the Basin, however, during the construction period, especially prior to capping the containment facilities, there will be a negative impact on the aesthetics of the area.

d) Costs

The 'Partial Dredging and Fill' option will require the expenditure of a significant sum of money. However, with the disposal area adjacent to the Basin the cost of disposal can be reduced compared to having to move sediment to an off-site disposal area.

The Hamilton Harbour Commissioners retained Mar-land Engineering Limited to prepare a proposal for the partial dredging of Windermere Basin with the development of containment areas within the Basin for the contaminated sediments. Two alternatives were initially presented by Mar-land Engineering Limited. One of the Mar-land alternatives was

selected as the preferred approach. This alternative is now being developed for the Windermere Basin clean-up.

The costs presented in the 1984 Mar-Land prefeasibility proposal were for containment of untreated sediment. The costs of the original two alternatives were:

Alternative No. 1	-	\$3.75 million
Alternative No. 2	-	\$3.79 million

Variations of the Mar-land prefeasibility proposal suggested by Envirosearch (1985) ranged in estimated cost from \$6 to \$7 million. Subsequent testing has verified that the additional expenses included in the Envirosearch proposals are no longer necessary. Modifications that permit the staging of construction and the bypassing of flow around the work area in Windermere Basin have been developed by Mar-land as part of the current project configuration.

e) Socio-Political Considerations

The 'Partial Dredging and Fill' option complements the expressed desire to clean up the Windermere Basin. The reduction of Basin area to create an on-site sediment disposal area is seen as the only practical way to avoid the problem of finding an acceptable off-site disposal area. This alternative does not create a situation that will generate the response "Not In My Back Yard" which could stop the project for a prolonged period of time.

3.2.4 Raise Water Level

Raising the water level by constructing a dam at the outlet from Windermere Basin would temporarily resolve the problem of having mudflats exposed to view during periods of low water. However, sedimentation would continue and eventually the sediment levels would accumulate to a point at which the mudflats were again exposed.

This solution would not address the problem of the contaminated sediments in the basin. The uptake of contaminants from the sediments would continue and the risk of sediment scour would remain. The sediments would continue to pose a potential hazard to waterfowl and aquatic life.

a) Environmental Concerns

Calculations indicate that under some runoff and storm conditions, flow through Windermere Basin could reach velocities that would promote the scouring of bottom sediment from the basin. The construction of a dam to raise water levels in the basin would do little to alleviate this problem. In fact, raised water levels could increase the risk of upstream flooding under storm conditions.

The resuspension of contaminants to the water column, as indicated by the 1983 Ontario Ministry of Environment water quality data, would continue.

If Windermere Basin is to remain a waterbody, it will eventually be necessary to remove sediment deposits from the Basin. By postponing a clean-up through raising water

levels, it is possible that the future rehabilitation of the basin could be made more difficult.

b) Environmental Benefits

In the short term, the hydraulics of flow through Windermere Basin would be improved slightly at low flows. This should result in some additional assimilative capacity in the basin.

The raising of water levels in Windermere Basin would contribute little benefit to the Basin. The problem of contaminated sediment being in contact with the overlaying water would remain.

c) Aesthetic Considerations

The raising of water levels could eliminate the exposure of mudflats due to the periodic fluctuations in water levels. There would be improvement in the appearance of the Basin, however, the problem of exposed mudflats would recur as sediments continue to accumulate and in time the aesthetic improvement would be lost.

d) Costs

The construction of a permanent dam to control water levels in the Basin would require a thorough engineering study to determine the pertinent design parameters. A relatively simple dyke structure could maintain water at a given level, however, it would be necessary to develop a dam with some form of control structure to permit passing flood flows to minimize the upstream flood risk. The type of structure

selected would affect the cost.

Envirosearch estimated prices (1985) for a weir structure across the outlet from the Windermere Basin based upon unit prices used by Mar-land in preparing their 1984 prefeasibility proposal. It was assumed that a dyke structure could be used with a spillway included to pass high flows. The cost was estimated at \$435,000.

e) Socio-Political Considerations

The raising of water levels would improve the appearance of the basin and hence may receive public support, however, the fact that contaminated sediment would still be exposed to the water column and continue to be a threat to waterfowl, is cause for concern.

3.2.5 Create Marsh on Mudflats

The creation of a marsh on the mudflats would involve the selective planting of aquatic plants in the mudflats such that the plants would eventually spread and cover the sediment area that is regularly exposed during low water periods.

This solution could be undertaken with a view to stabilizing the mudflat deposits and reducing the risk of sediments in the mudflats from being scoured from the basin. No flow or water level control structure would be included in this scheme.

a) Environmental Concerns

This alternative involves no sediment removal. As a result, the chance of sediment scour under high flows such as a Regional Storm would still exist but at a somewhat reduced level in that the root mat associated with the plants would tend to stabilize the sediment and reduce its susceptibility to scouring. The hazard to wildlife could increase in that the aquatic plants might attract increased numbers of waterfowl. Once an aquatic plant regime is established there would still be a risk that aquatic life and waterfowl would be exposed to high levels of contaminants that could prove to be toxic to some species. This could result from continued exposure to the sediments in the basin or it could occur as a result of contaminate uptake in aquatic plants under some conditions of fluctuating water levels.

One risk with this option is that the aquatic plants might not take root and survive. Work that has been undertaken by the U.S. Army Corps of Engineers has demonstrated that aquatic plants can be a viable approach to stabilizing sediments, however, the period of time required to create a dense enough root mat to protect the sediments could be several years. There could also be a considerable period of experimental planting required to find the right species that would tolerate the contaminants in the sediment, survive in the fluctuating water levels and be environmentally acceptable.

During high water periods of the year, the plants would be submerged whereas at times of low water levels the plant and root mat would be exposed. It has been demonstrated that under circumstances in which the root is not continually submerged, some aquatic plants will uptake and release metals and pollutants to the environment. This could result in an ongoing release of toxic materials, possibly at a greater rate than if no plant life were present. This could present an additional hazard for wildlife.

The absence of plants on the mudflat at present indicates possible problems in culturing aquatic plants in the basin without making significant physical changes to the basin. If plants were to be established, it is not possible to predict if ongoing sedimentation in the basin would eventually suffocate the plants, or whether the plants would spread onto the newly deposited sediments.

There is insufficient information available to be able to come to a supportable conclusion as to the extent of the environmental risks associated with this alternative. The major concern is the likelihood of sediment scouring during storm events and affecting and contaminating portions of the harbour.

b) Environmental Benefits

The long term benefit to Windermere Basin from establishing aquatic plants in the mudflats would relate to the stabilization of the sediments and the elimination of the view of

barren mudflats during periods of low water. A portion of the existing assimilative capacity of the basin would be maintained.

c) Aesthetic Considerations

With the creation of a marsh environment in the areas of the Basin in which mudflats are regularly exposed the presence of the aquatic plants could be seen to enhance the aesthetics of the area.

d) Costs

The establishment of a marsh environment in the mudflat areas would involve labour intensive work that would have to be undertaken in stages. Initially, there would have to be experimental plantings followed at a later date by a full-scale planting program. The cost of this type of work would be relatively low in comparison to other structural or dredge dependent options.

An initial estimate of the studies that should be undertaken to confirm the probable success of a marsh stabilization project for the mudflats plus an estimate for the cost of labour to undertake the project indicates that the total cost could be in the order of \$500,000.

e) Socio-Political Considerations

The creation of a marsh environment on the mudflat areas of the basin is a sacrificial type of action in which the surface area of the Basin would be reduced. With the general opposition to filling the basin, it is questionable whether

barren mudflats during periods of low water. A portion of the existing assimilative capacity of the basin would be maintained.

c) Aesthetic Considerations

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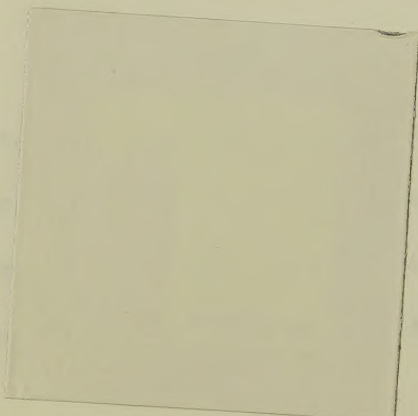
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this alternative would be welcomed in that the type of marsh that would be created would essentially be the final stages in an environmental conversion from an aquatic to a terrestrial environment.

3.2.6 Create an Engineered Tertiary Treatment Marsh

The creation of an engineered tertiary treatment marsh would involve removing the contaminated sediments from the basin and using these sediments as shore area fill. Water level control berms, flow distribution channels and sediment traps could also be created to provide an environment in which aquatic plants could be cultured to create a marsh. The marsh could become a tertiary treatment facility for the Woodward Avenue Sewage Treatment Plant. A sediment trap area within the basin could reduce the volume of sediments passing through the Basin into Hamilton Harbour. The shore disposal area would have to be designed for the containment of highly contaminated sediments or alternatively the sediments may have to be stabilized prior to being placed in the containment area.

The creation of an engineered marsh to serve as a tertiary treatment facility for the Woodward Avenue Sewage Treatment Plant and to act as a settling basin to trap solids from Redhill Creek would necessitate that the basin be dredged, and a series of berms be constructed to maintain minimum water levels in the marsh area. The berms could direct all dry weather flow through the marsh portion of the Basin.

while permitting the bypassing of high flows around the marsh. The settling basins would be designed to remove solids and reduce the rate of solids loading on the downstream areas of the harbour.

A berm could be constructed along the southerly and westerly sides of the Basin to permit fill operations adjacent to the Stelco and National Slag properties. The proposal would involve the removal of contaminated sediment from the Basin and the placing of these materials behind the berm. Berms would be constructed to control flow at the inlet end of the marsh near the Sewage Treatment Plant, and along the north side of the Basin. Water levels in the marsh would be maintained relatively constant.

a) Environmental Concerns

The major concern associated with this alternative is the loss of pollutants to the aquatic environment during the removal of contaminated sediments from the Basin. Losses could also occur during the placement of the sediments in the disposal area.

There is also the concern that wildlife could be exposed to pollutants in the sediment disposal area prior to capping.

b) Environmental Benefits

The hydraulics of flow through Windermere Basin would be improved. This would provide an opportunity to create a sediment trap in the basin that could reduce the need for

maintenance dredging further downstream in the approach channel to the Strathearne slip and in the areas adjacent to the East Port pier facilities.

The removal of the contaminated sediments would reduce the risk of pollutant resuspension into the water column, thereby reducing the risk of discharging these materials to Hamilton Harbour or possibly to Lake Ontario.

The assimilative capacity of the Basin would be increased if the sediments having a high sediment oxygen demand were removed and aquatic plants were planted to create a marsh environment. This would provide additional treatment to the effluent from the Woodward Avenue Sewage Treatment Plant prior to its discharge to Hamilton Harbour.

c) Aesthetic Considerations

The removal of the sediments from the Basin could eliminate the exposure of mudflats during periods of low water levels. The aesthetics of the Basin area would be improved through the creation of areas with aquatic plants.

d) Costs

An 'Engineered Tertiary Treatment Marsh' would require the expenditure of a significant sum of money for the contaminated sediment removal portion of the work, plus associated berms and sediment trap dredging as well as establishing aquatic plant cultures.

In undertaking the filling of the Basin it would be necessary to construct berms that would delineate the channel through the basin. Some dredging would be required to remove contaminated sediment from the new channel. Filling could then take place without the risk of displacing bottom sediment into Hamilton Harbour.

a) Environmental Concerns

Channelizing and filling Windermere Basin would result in all sediments currently being discharged from Redhill Creek and the Woodward Avenue Sewage Treatment Plant being passed through into Hamilton Harbour. In addition, the oxygen demand loadings from the Sewage Treatment Plant would not be reduced and consequently, an additional oxygen demand loading would be discharged to the Harbour.

The Basin would have to be dyked prior to filling or else the filling process would result in the displacement of contaminated sediment to Hamilton Harbour. If the Basin is dyked to protect the Harbour, a stagnant pond would then be created for the duration of the filling process. This in turn could create hazardous conditions for waterfowl and other aquatic life in the area.

The aesthetics of the basin would be severely degraded throughout the period of the fill activities.

b) Environmental Benefits

Eventually the contaminated sediments in the basin would be covered over with clean fill.

c) Aesthetic Considerations

The elimination of the basin would see future development and an end to any possible waterbody setting. During the short term while the fill work would be in progress, the aesthetics of the area would deteriorate.

d) Costs

If the project were undertaken over a prolonged period of time when there was significant construction activity in the Hamilton area, the fill could be obtained and placed with minimal capital expenditure.

The major cost would be for the construction of the berms and the shaping of the fill material. The costs for filling the Basin was estimated to be \$1,900,000. The cost could be more than offset in that at an estimated market value in the order of \$50,000 to \$65,000 per acre (\$124,000 to \$160,000 per hectare), approximately 20 hectares of reclaimed land should be marketable at \$2.5 to \$3.2 million.

e) Socio-Political Considerations

Filling Windermere Basin would be counter to the current desires of the public to have the harbour area upgraded and 'beautified'.

3.3 RANKING of ALTERNATIVES

Envirosearch (1985) concluded that the water quality data indicated some quality degradation within Windermere Basin and the associated sediment data indicated gross contamination of the sediments throughout the Basin. An accompanying analysis of flow velocities through the Basin indicated that velocities in excess of levels known to cause scouring could be expected each year. The analysis also indicated that there was a significant risk of scouring of contaminated sediments from Windermere Basin should a major storm event occur.

The Envirosearch report concluded that there was justification for taking action to isolate the contaminated sediments in Windermere Basin from the environment.

The alternatives that were discussed in the 1985 Envirosearch report are summarized in Table 2. These alternatives were not all found to fulfill the objective of isolating the contaminated sediments.

The 'Do Nothing', 'Create Marsh' and 'Raise Water Level' options would continue to permit intimate contact between the contaminated sediments and the water flowing through the Basin and aquatic life in the Basin. Creating a marsh or raising the water level could provide some aesthetic improvements in the Basin, but the existing risk of water quality degradation would remain as would the potential hazard to aquatic life.

TABLE 2
WINDERMERE BASIN STUDY - SEDIMENT DISPOSAL ALTERNATIVES

OPTIONS	DO NOTHING	DREDGE AND LANDFILL	DREDGE AND INCINERATE
ENVIRONMENTAL CONCERNS	-scour sediment in regional storm. -contaminated area for waterfowl & aquatic life. -assimilative capacity decreasing from sedimentation. -increasing sediment transport to harbour. -eventually cleanup would still be required.	-loss of contaminants during dredging. -complete dredging will need offsite disposal. -existing suitable disposal sites costly. -to license new site will be opposed by neighbours.	-loss of contaminants during dredging. -incinerate sediment at Woodward Avenue Sewage Treatment Plant
ENVIRONMENTAL BENEFIT	-none	-improved hydraulics. -improved assimilative capacity. -eliminates exposed contaminants. -offsite disposal ensures no leaching.	-improved hydraulics. -improved assimilative capacity. -eliminates exposed contaminants. -incineration of sediment ensures no leaching.
SOCIO-POLITICAL CONSIDERATIONS	-poor image -has been an expressed interest in cleanup of basin. -contravenes 'BEAUTIFY HARBOUR' concept.	-expect 'NIMBY' response in vicinity of disposal area. -double problem of contaminated sediment for disposal & excess truck traffic to disposal site.	-violation of phosphorus criteria for Woodward Avenue Sewage Treatment Plant.
AESTHETICS	-unsatisfactory.	-improved.	-improved.
COSTING	-nil	\$22.9 to \$35.1 million	\$19.1 million

TABLE 2 (CONT'D -1)

WINDERMERE BASIN STUDY - SEDIMENT DISPOSAL ALTERNATIVES

OPTIONS	PARTIAL DREDGE & FILL	DREDGE-STABILIZE-FILL	RAISE WATER LEVEL
ENVIRONMENTAL CONCERNS	-loss of contaminants during dredging. -use portion of basin as a disposal area. -will have to secure disposal area against loss of contaminants in sediment. -reduced surface area will lower assimilative capacity potential.	-loss of contaminants during dredging. -use portion of basin for disposal area. -stabilizat'n increases volume to be disposed. -reduced surface area will lower assimilative capacity.	-contaminated sediments remain. -sediments still likely to scour in regional storm. -contaminated area for waterfowl & aquatic life. -likely to increase upstream flooding potential. -eventually cleanup would still be required.
ENVIRONMENTAL BENEFIT	-improved hydraulics. -eliminates exposed contaminants. -reduced hazard to wildlife.	-improved hydraulics. -eliminates exposed contaminants. -reduced risk of contaminated leachate.	-buys time. -cosmetic.
SOCIO- POLITICAL CONSIDERATIONS	-is reduced surface area acceptable?	-is reduced surface area acceptable?	-will public accept a short term cosmetic improvement.
AESTHETICS	-some improvement.	-some improvement.	-short term cosmetic improvement.
COSTING	\$3.96 to \$4.0 million	\$6.0 to \$6.79 million	\$435,000

TABLE 2 (CONT'D -2)
WINDERMERE BASIN STUDY - SEDIMENT DISPOSAL ALTERNATIVES

OPTIONS	CREATE MARSH	TERTIARY TREAT'T MARSH	CHANNELIZE & FILL
ENVIRONMENTAL CONCERNS	-attract wildlife to contaminated sediments. -current conditions don't support aquatic plant growth. -reduced open water could lead to loss of dissolved oxygen in basin.	-loss of contaminants during dredging. -use portion of basin for disposal area. -will have to secure disposal area against loss of contaminants in sediment or stabilize sediment.	-reduction in surface would reduce assimilat'n potential. -all sediment would be discharged to harbour. -if berm to reduce loss of contaminants during filling will have a large stagnant pond. -loss of aquatic environment.
ENVIRONMENTAL BENEFIT	-aquatic plants hide sludge banks. -aquatic plants might stabilize sludge.	-improved hydraulics. -eliminates exposed contaminants. -additional treatment for STP effluent. -additional aquatic habitat.	-would eventually isolate contaminants from aquatic environment.
SOCIO-POLITICAL CONSIDERATIONS	-is marsh accepted as beneficial area or as 'more weeds'.	-not fill but is treatment marsh desired alternative.	-should the waterbody be eliminated. -is additional land required.
AESTHETICS	-may or may not be seen as an improvement.	-may or may not be seen as an improvement.	-is filled land area an aesthetic improvement?
COSTING	\$500,000	\$6.4 to \$7.15 million	\$1.9 million

Channelizing and filling the Basin could resolve the problem of having the sediments exposed to the overlying water, but the solution would destroy what was to originally be preserved (i.e. Windermere Basin).

The complete dredging of the Basin with the sediments being either incinerated or trucked to a landfill could accomplish the original goal, however, the \$22.9 to \$35.1 million price tag for the clean-up was considered to be very expensive.

Envirosearch (1985) identified a series of options that were considered to warrant further investigation as possible solutions for the isolation of the contaminated sediments in the Windermere Basin.

The options identified were:

- 1 - Partial Dredge and Fill;
- 2 - Dredge, Stabilize and Fill;
- 3 - Dredge, Stabilize and Create a Tertiary Treatment Marsh.

It was concluded that if the original objective of preserving the Basin was foregone, then a fourth option could include the 'Channelize and Fill' alternative.

These findings were reported to the Windermere Basin Technical Advisory Committee for their consideration.

4.0 SELECTION OF AN ALTERNATIVE

The Windermere Basin Technical Advisory Committee reviewed the alternatives listed in Table 2 that had been identified by Envirosearch. The Committee reported:

"Although the chemical stabilization (fixation) of dredgate is not a proven science, enough research data is available to conclude that fixation will make it more difficult for toxic substances to escape into the environment. There are, however, a number of problems with the fixation technique, not the least one being its cost. (Estimated cost of dredging and regular disposal - \$4,400,000; dredging and disposal with stabilization of dredgate - \$7,700,000). In addition, there is the problem of increased volume. The fixation process involves the addition of considerable quantities of fly ash lime (or other suitable additives) to the dredgate which would more than double its final volume. This added volume would obviously aggravate the disposal problem."

In view of the the fact that the original tests to determine whether the sediments were 'hazardous' were not conducted properly, the Committee sought clarification by requesting new testing of basin sediments. The Wastewater Technology Centre was requested to undertake additional testing including the Ontario testing procedures to determine whether the sediments were 'hazardous'. The tests (WTC 1986) confirmed the sediments were 'non-hazardous' and that stabilization prior to disposal was not required to ensure that sediment contaminants did not migrate from the disposal site.

In the light of the Wastewater Technology Centre study, the Committee concluded that "fixation would not be necessary". Having rejected the need for stabilization and rejected the alternatives involving off-site sediment disposal and the

channelizing and filling of the Windermere Basin, the committee was left with the alternative of partial dredging with the disposal of contaminated sediments in confined disposal areas within the Windermere Basin.

4.1 SELECTED ALTERNATIVE

The Windermere Basin Technical Advisory Committee recommended:

- "1. That the basin be partially dredged
2. That the sediments be disposed of on site behind containment berms.
3. That the sediments be disposed of without chemical stabilization."

The Committee also addressed a series of questions related to the clean-up of Windermere Basin. The questions addressed and the Committee response follow.

How much sediment should be removed?

Committee recommendation:

"To make the project effective, it is important that seriously contaminated sediments be removed from contact with open water. Generally, this will involve the top 70 centimeters, although the actual depth will vary from location to location. Taking the above criterion in mind, it is estimated that a minimum of 280,000 cubic meters of sediment is to be removed from open water contact. There will be no requirement to remove contaminated sediment from the designated disposal areas."

Which area of the basin should be set aside as a sediment disposal area?

Committee recommendation:

"Several locations with different configurations are feasible. A final selection will, to a large extent,

depend on design considerations, the ultimate use to be made of the containment area, and the ownership of the basin."

How much water volume and surface area should be maintained?

Committee recommendation:

"It is important to maintain as large a water volume and water surface area as possible. Volume is required to make the basin functional as a sediment settling area. A substantial water surface area is important as it increases the basin's capacity to absorb oxygen from the atmosphere. Considering the quantity of fill to be disposed of it should be possible to maintain at least 50% of the basin's surface area."

What precautionary measures should be taken during the sediment removal process?

Committee recommendation:

"Measures must be taken during the dredging process to minimize the transportation of contaminated sediment from the basin to the harbour and possibly Lake Ontario. The area to be dredged must therefore be isolated during the dredging operation. There are a range of possibilities, e.g.

- A system of weirs
- Bubble curtains
- Silt curtains
- Bypass channels.

The final design is to determine the best system to use."

What should be the ultimate land use of the dredgate disposal area once the dredging is completed?

Committee recommendation:

"This question is considered to be beyond the mandate of the committee and was therefore not dealt with. Decisions on land use matters must be made through normal Regional and City planning procedures."

How can the project be of benefit to improve the aesthetics of the basin?

Committee recommendation:

"The dredging of the basin offers an excellent opportunity to improve the aesthetics of the area. The degree of this improvement will, to a large extent, depend on the location and configuration of the disposal areas as well as their ultimate use. Although members expressed certain points of view on this question, it was considered to be beyond the committee's mandate to make recommendations and/or suggestions."

Which agency should be the project proponent?

Committee recommendation:

"The Hamilton Harbour Commissioners have offered to be the project proponent. Both Regional and City Councils have accepted this offer. It is the opinion of the committee that the Hamilton Harbour Commissioners would be a suitable proponent, subject to all requirements respecting environmental and land use issues being met wherever they apply."

Will it be necessary to undertake an environmental assessment before the project is started?

Committee recommendation:

"Since the Hamilton Harbour Commissioners will be the likely project proponents, it is expected that a Federal environmental project appraisal will be required. The work done by the Windermere Basin Technical Committee and the technical reports produced will greatly assist in streamlining the process."

What preventative measures should be undertaken to prevent a similar situation from recurring?

Committee recommendation:

"It is essential that a long term commitment on maintenance and preventative measures be made. Preventative measures would include the following:

- An urban stormwater management program for Redhill

Creek (Cities of Hamilton and Stoney Creek, Township of Glanbrook)

- The control of combined sewer overflows
- Upstream erosion control measures (Conservation Authority, Region, City, landowners)
- The setting of high water quality standards for all effluent discharging into the basin (MOE)

In spite of these long range preventative measures, it is expected that some sediments will continue to settle in the basin. The final design of the basin should be such to allow for the trapping of the sediments in special settling areas. These settling areas will require periodic dredging."

The committee went on to conclude that:

"the rehabilitation of the Windermere Basin is one of the highest environmental and aesthetic issues in the Region. After much research and debate, there now appears to be a viable solution".

4.1.1 Most Viable Alternative

The recommendation of the Windermere Basin Technical Advisory Committee to undertake the partial dredging of the basin with the creation of a sediment disposal facility within portions of the Windermere Basin is supported by the findings of previous investigators.

A total of nine alternatives were investigated in the Envirosearch report that was prepared for the Windermere Basin Technical Advisory Committee. While all options were considered to be technically possible, the viability of these alternatives varied.

The 'do nothing', 'raise water level' and 'create marsh on the mudflats' alternatives never addressed the critical question of isolating the contaminated sediments from the

overlying water column. This lead the committee to dismiss these alternatives as not being acceptable.

The Envirosearch alternatives that included the stabilization of the sediment prior to being placed in disposal facilities within the basin would pose a significant problem. The volume of the stabilized sediment would be approximately double the volume of the material dredged from the basin (Trow 1983). It would be difficult to maintain as much of the basin volume and surface area as possible if the sediment were stabilized. In addition, the cost would nearly double if sediment stabilization were undertaken. The above, coupled with the Wastewater Technology Centre findings (1986) that contaminants could be suitably confined in dyked sediment disposal areas, making stabilization unnecessary, confirmed the viability of a conventional confined disposal area. With these facts, the Windermere Basin Technical Advisory Committee concluded that the on-site disposal alternative using conventional confined disposal was acceptable and the use of sediment stabilization was unnecessary.

The complete dredging alternatives were discounted for a number of reasons. The logistics problem in trucking sediment including the risks posed by large scale transport of the contaminated materials on the road system, the cost to haul the dewatered sediment to off-site disposal areas plus the tippage fees to landfill the sediment would make these alternatives both impractical and very expensive. An even more crucial factor was the absence of any suitable off-site

disposal facility nearby. As a consequence, it would be necessary to create a new disposal facility. The likelihood of receiving approval for such a facility was considered to be extremely remote.

The alternative to incinerate the sediment at the nearby Woodward Avenue Sewage Treatment Plant was costly plus, it would have also meant putting the plant in serious violation of the Canada-Ontario Great Lakes Water Quality Agreement. The several years that would have been required to undertake this alternative further reduced the desirability of the alternative.

In summary, it was concluded that the partial dredge and fill option was one of the most environmentally safe alternatives. The amount of sediment dredging could be minimized through the judicious selection of the sediment disposal area. The work areas could be isolated through a staged construction programme that would permit bypassing the sewage treatment plant effluent and Redhill Creek streamflow during the clean-up. This would minimize the loss of contaminants from the sediment. Once confined, the sediments could be isolated from the adjacent waterbody. This combination of minimal environmental impact plus a least cost clean-up were factors favouring the partial dredge and fill option.

4.1.2 Partial Dredge/Fill Configuration

The partial dredge and fill option was first identified by Mar-land Engineering Limited in 1984 in their Prefeasibility Study - Proposed Improvements To Windermere Basin. The 1984 report identified two alternatives (I and II). These alternative configurations are presented in Figures 7 and 8.

The Alternative I configuration would minimize the amount of contaminated sediment removal in that the disposal area would encompass the majority of the existing sludge bank. Unfortunately, the surface area of the water remaining in Windermere Basin would only be in the order of 18.4 hectares or 41% of the before clean-up basin area. The Alternative II concept involved changing the location of the containment berms such that the north-east sediment disposal area was reduced from approximately 18.6 to 12.5 hectares in size. The south and west shore disposal areas would increase from approximately 6.7 to 11.1 hectares. These changes would permit the retention of a relatively centrally located water area of 20.1 hectares (46% of the before clean-up basin). The net volume of the basin will increase from 28% to 128% depending on the water level.

The project is similar to the Alternative II proposal described in the 1984 Mar-land report. The current concept includes some changes to the berm configuration to minimize problems associated with passing peak flows through the basin. An hydraulic model has been constructed to determine the best layout for sediment trap areas and to verify and

HAMILTON HARBOUR

ROAD/RAIL
BRIDGE

LAKE ONTARIO

BEACH
BLVD.

SHORELINE #0.47m

Q.E.W.

PROP. PROVINCIAL ARTERIAL RD.

PIER - 24

DREDGE
DEPTH EL. -4.0m.

CONTAINMENT
AREA
= 18.64 ha. (A)

DREDGE
DEPTH EL. -1.5m.

BASIN
AREA = 18.35 ha.

DREDGE
DEPTH EL. -4.0m.

CONTAINMENT
AREA
= 4.01 ha. (B)

BERM = 500 m.

BERM = 1000 m.

DREDGE
DEPTH EL. -1.0m.

DREDGE
DEPTH EL. -4.0m.

LANDFILL
AREA
= 2.72 ha. (C)

WOODWARD AVE.

REDHILL CREEK

ALTERNATIVE (I)

PREFEASIBILITY STUDY

FOR IMPROVEMENTS TO WINDERMERE BASIN
MAR-LAND ENGINEERING LIMITED



Fig. 7

HAMILTON HARBOUR

LAKE ONTARIO

ROAD/RAIL
BRIDGE

BEACH

BLVD.

STORM OUTFALL
(TO BE EXTENDED)

PROP. PROVINCIAL ARTERIAL RD.
Q.E.W.

PIER - 24

DREDGE
DEPTH EL. - 4.0 m.

H.H.C. WATERLOTS

DREDGE
DEPTH EL. - 1.5 m

CONTAINMENT
AREA A
= 12.47 ha.

BASIN
AREA = 20.14 ha.

STELCO WATERLOTS

CONTAINMENT
AREA B
= 11.11 ha.

BERM = 970 m.

SLUDGE BANK

DREDGE
DEPTH EL. - 1.0 m.

WOODWARD AVE.

REDHILL
CREEK

RATIO OF WATER/LAND = 0.85
RATIO OF NEW BASIN/ORIGINAL = 0.46

50 0 100 m.

ALTERNATIVE II

PREFEASIBILITY STUDY

FOR IMPROVEMENTS TO WINDERMERE BASIN
MAR-LAND ENGINEERING LIMITED

Fig. 8

fine tune armouring requirements for the portions of the north inlet berm that will be most severely impacted by the peak flow discharges from the Redhill Creek.

The sediment disposal areas are being segmented with internal cut-off berms to facilitate better solids recapture during the dredging process. In addition, the internal berms will make it easier to work on the sediment surface during post dredging capping operations.

4.1.3 Proposed Design

The proposed design involves a staged construction programme that will minimize the risk of sediment losses to the overlying water and subsequently Hamilton Harbour and Lake Ontario.

The proposed configuration of the finished project is presented in Figure 9. The actual construction will be staged as indicated in Figures 10, 11 and 12.

The first stage of the clean-up (Figure 10) will involve the construction of a weir at the outlet from the Windermere Basin plus the construction of a portion of the eventual containment berms in the vicinity of the mouth of Redhill Creek at the south easterly end of the basin.

The weir will be earth construction with a centre section dropped to permit water to overflow at an elevation of approximately 74.8 metres. The centre overflow will be protected with a stone lining to permit overflow without

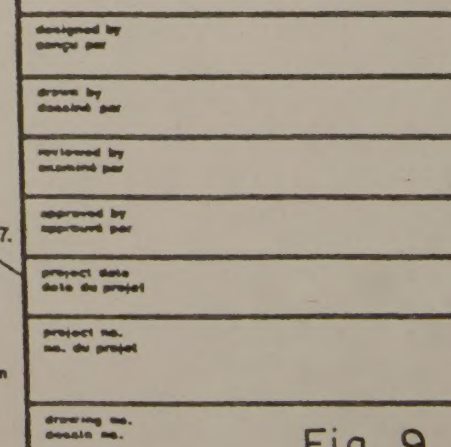
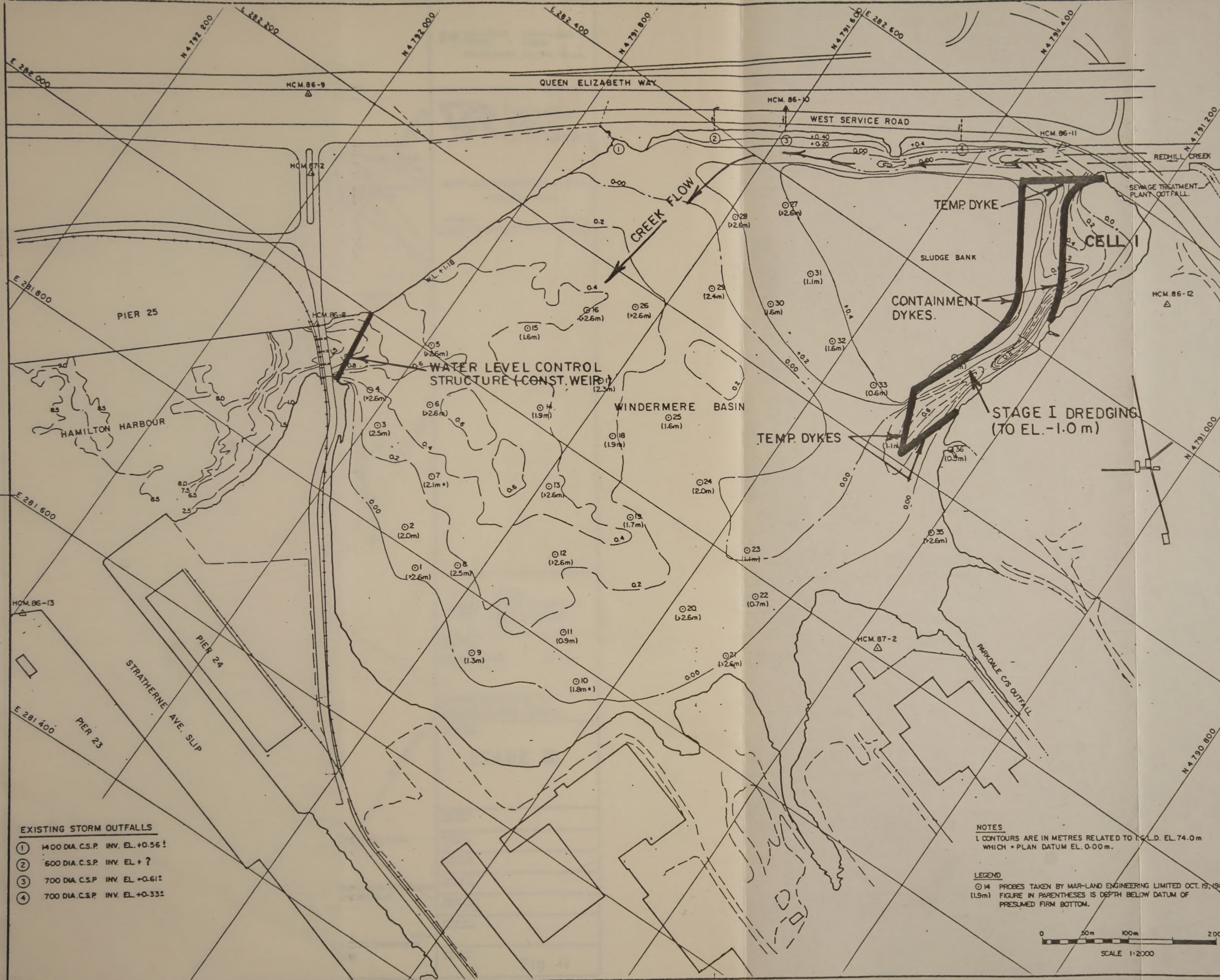


Fig. 9



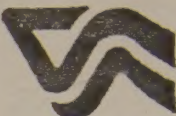


Public Works
Canada



Travaux publics
Canada

Ontario Region Région de l'Ontario



The Hamilton
Harbour
Commissioners

MAR-LAND ENGINEERING LIMITED
CONSULTING ENGINEERS

MARSHAM ONTARIO

A

B

C

A detail no.
no. du détail

B drawing no. - where detail required
dessin no. - où détail requis

C drawing no. - where detailed
dessin no. - où détaillé

project title
titre du projet

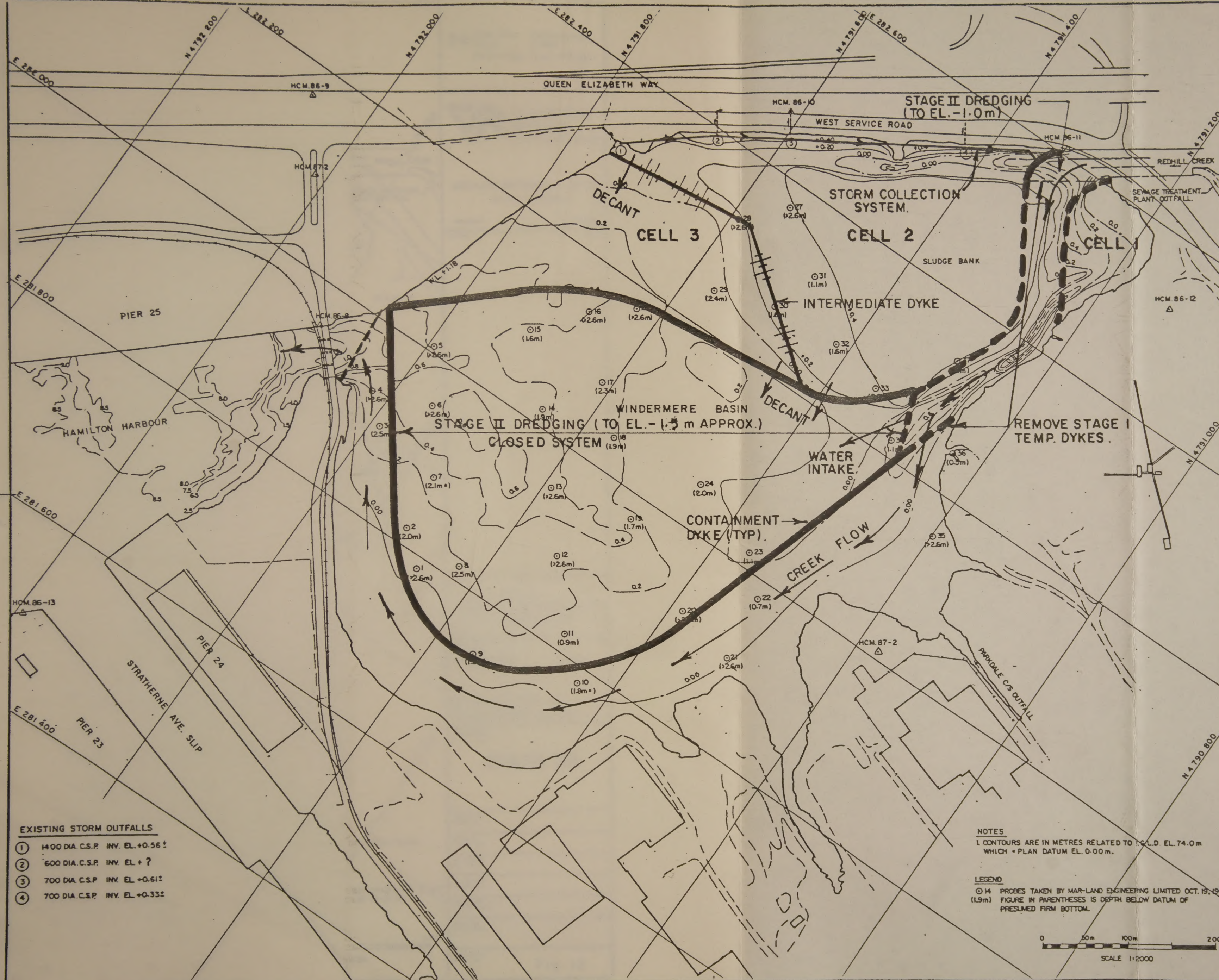
HAMILTON ONTARIO

IMPROVEMENTS TO
WINDERMERE BASINdrawing title
titre du dessin

STAGE I

designed by
conçu pardrawn by
dessiné parreviewed by
examiné parapproved by
approuvé parproject date
date du projetproject no.
no. du projetdrawing no.
dessin no.

Fig. 10



A detail no.
no. du détail

B drawing no. - where detail required
dessin no. - où détail exigé

C drawing no. - where detailed
dessin no. - où détaillé

project title
where the project

HAMILTON ONTARIO

IMPROVEMENTS TO WINDERMERE BASIN

drawing title
titre du dessin

STAGE II

Designed by
George Bell

Drawn by _____
 checked per _____

not learned by
conventional path

and
by

project date
date du projet

五言古詩
五言律詩

Ordering info.

Fig. 11

A	detail no.
B	drawing no. - where detail required
C	drawing no. - where detailed

project title
titre du projet
HAMILTON ONTARIO

IMPROVEMENTS TO
WINDERMERE BASIN

drawing title
titre du dessin

STAGE III

designed by
conçu par

drawn by
dessiné par

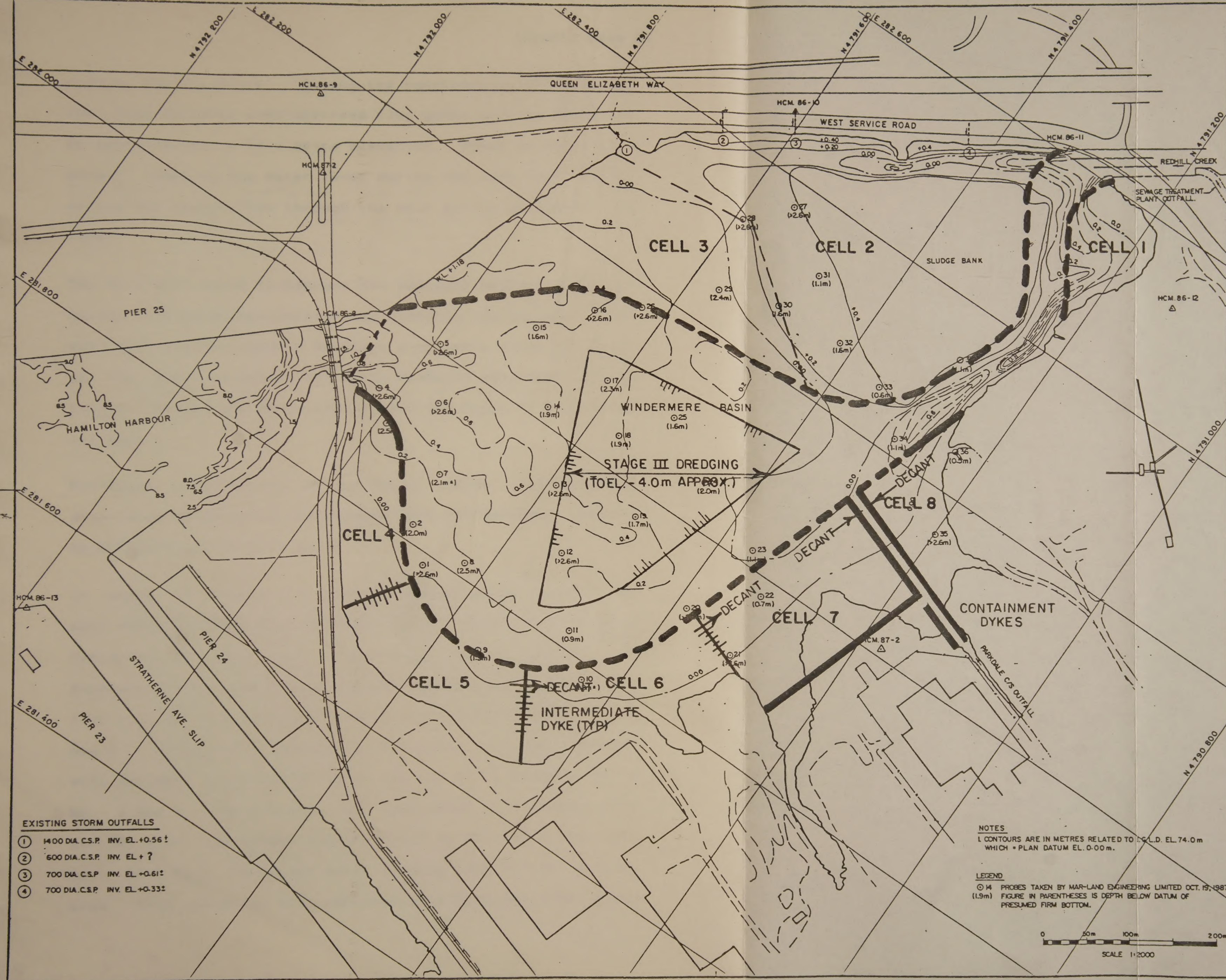
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date du projet

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no. du projet

drawing no.
dessin no.



EXISTING STORM OUTFALLS

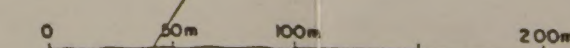
- ① 1400 DIA. C.S.P. INV. EL. +0.56
- ② 600 DIA. C.S.P. INV. EL. + ?
- ③ 700 DIA. C.S.P. INV. EL. +0.61
- ④ 700 DIA. C.S.P. INV. EL. +0.33

NOTES

1. CONTOURS ARE IN METRES RELATED TO C.L.D. EL. 74.0m
WHICH = PLAN DATUM EL. 0.00m.

LEGEND

① 14 PROBES TAKEN BY MAR-LAND ENGINEERING LIMITED OCT. 19, 1987.
(1.9m) FIGURE IN PARENTHESES IS DEPTH BELOW DATUM OF
PRESUMED FIRM BOTTOM.



eroding the structure. During the construction of the weir, low flow culverts with upstream flap gates will be installed at approximately a 74.4 metre elevation. These culverts will permit lowering the water level during the 1989-1990 winter period and permit flow through the weir during periods of low flow.

The weir will serve to capture the sediment bedload generated during the berm construction and dredging activities. The weir will also be used to maintain a suitable depth of water in the basin to permit hydraulic dredging equipment to be safely floated and manouvered during the Stage II and Stage III work.

Following construction of the Stage I berms, the enclosed area will be mechanically dredged with the sediment removed being deposited in Cell No. 1.

In stage II (Figure 11), the containment berms forming the post dredging basin will be constructed. These berms will be connected to the stage I berms such as to isolate the disposal cells 2 and 3 from the main body of the basin. All flow will be diverted around the south and west sides of the basin. Hydraulic dredging of the basin will then proceed with sediment being deposited in the two north easterly Cells No. 2 and 3. The dredging will take place in a closed loop system with the dredge pumping first to Cell No.2 and then Cell No.3 with the decant water flowing back to the working area. This operation will continue with both Cells No. 2 and

3 being used alternatively until the seriously contaminated sediment has been removed from the open water area of the basin.

During stage III (Figure 12), the berms will be modified to route flow through the basin while the final depths are dredged and the dredged sediment is deposited in the Cells No.4 through 8 located along the south, west and northwest sides of the basin. This would then be essentially an open system.

The confined disposal area Cells No. 1, 2 and 3 will be permitted to self-consolidate throughout 1989. Cells No. 4 through 8 will be filled during 1989 and allowed to dewater until the winter period of early 1990. During the early part of 1990 when a crust freezes over the cells, the Hamilton Harbour Commissioners will undertake to place a 1.0 metre cap of clean material over the dredged material in the confined disposal area cells. The capping material will be dumped along the cell berms and worked in toward the centre of each cell using a bulldozer. The work will proceed on several cells concurrently at a rate that permits frost penetration of the placed capping material such that adequate strength is developed in the cap to support the equipment being used in the capping operation. Following the completion of the capping procedures, the weir will be removed and the water levels in the basin permitted to fluctuate with the level of Hamilton Harbour (i.e. the natural state).

5.0 DESCRIPTION OF THE PROJECT ENVIRONMENT

The environment related to the project is the area around the southeast portion of Hamilton Harbour.

This section of the harbour, Windermere Basin, has gradually become degraded over the years through the deposition of contaminated sediments. Testing has shown that in general, the top 20 to 30 centimetres of sediments contain the most serious contamination with lesser degrees of contamination occurring in the sediments lying in the range of 30 to 60 centimetres in depth. Sediments in some areas of the basin, specifically the mudflat that is exposed during low water levels, could contain contaminants to greater depths.

The analysis of the sediments indicates that they are of light density with a high organic content. The nature of the sediments makes them susceptible to being resuspended into the water column under high flow conditions. The Wastewater Technology Centre has shown (WTC 1986) that the sediments are such that they can be safely isolated in a confined disposal area with minimum risk of the contaminants being leached from the disposal area back into the adjacent waters. The sediments have been tested using Ontario Ministry of Environment procedures and have been found to be 'non-hazardous' as defined by Ontario Regulation 309.

The absence of aquatic plants in the majority of the shallow areas and mortalities in the populations of waterfowl that have overwintered in the basin provides evidence that it may

not be possible to establish a healthy population of flora and fauna in Windermere Basin under existing conditions.

The accumulation of contaminated sediments has caused considerable damage to the Windermere Basin ecology. Studies by MOE 1982, Envirosearch 1985 and Persaud 1987 have documented sediment related environmental degradation.

If the contaminated sediments could be retained within Windermere Basin, the damage to the surrounding ecology would be limited. However, maintenance dredging operations in the Strathearne Avenue Approach Channel have demonstrated that contaminated sediment is migrating from Windermere Basin. Theoretical calculations, Envirosearch (1985), indicate that there is an ongoing loss of sediment from the basin during periods of high flows. This loss of contaminated sediments creates impairment that affects the water, sediments and biota in downstream sections of Hamilton Harbour.

5.1 The Physical Environment

Windermere Basin is surrounded by industrial development on the south and west, the Hamilton Harbour Commissioners' East Port facilities on the north, the Queen Elizabeth Highway and the East Port arterial road on the east and the Hamilton water and sewage treatment plants and the Woodward Avenue and Burlington Street arterial roads on the southeast.

The Windermere Basin receives the streamflow from Redhill Creek, effluent from the Woodward Avenue Sewage Treatment

Plant, combined sewage overflows from the Parkdale Avenue combined sewer and storm drainage from portions of the East Port facilities, the Queen Elizabeth Highway and the East Port Drive. The Redhill Creek has been the recipient of combined sewage bypasses for several years. In 1987, Hamilton-Wentworth completed the construction of the Greenhill stormwater holding facility to intercept approximately 95% of the combined sewage bypasses previously discharged to the Redhill Creek at Greenhill Avenue. Recent changes in the operations at the Woodward Avenue Sewage Treatment Plant have facilitated a considerable reduction in the combined sewage overflow discharges from the sewage collection system and the raw sewage by-passes at the sewage treatment plant that were previously discharging to the Windermere Basin. The average flow through the Windermere Basin includes 60,500 cubic metres per day from Redhill Creek and 340,000 cubic metres per day (75 MGD) of effluent from the Woodward Avenue Sewage Treatment Plant. The Ontario Ministry of Environment estimated (1982) that combined sewage bypassing to Windermere Basin averaged 4,000 cubic metres per day.

Effluent from the Woodward Avenue Sewage Treatment Plant makes up 85% of the inflow water to Windermere Basin. The combination of a relatively high rate of flow plus the elevated temperature that is traditionally associated with sewage treatment plant effluent results in the Windermere Basin remaining virtually ice-free throughout the winter.

The actual basin is clogged with accumulations of sediment and debris that seriously detracts from its appearance for prolonged periods each year when water levels are low. This accumulation of sediment and debris is blatantly obvious from the adjacent arterial roads and the Queen Elizabeth Highway. The present condition of Windermere Basin is such that it offers little aesthetic appeal. The resultant poor impression derived from the Windermere Basin does not complement the efforts being put forward by the City and Regional governments and local authorities and organizations to beautify and enhance the Hamilton environment.

Ontario is currently engaged in a programme to enlarge the Queen Elizabeth Highway and the Region of Hamilton-Wentworth has plans for the construction of a major arterial access highway linking the Queen Elizabeth Highway with the southern sections of Hamilton. The Queen Elizabeth Highway is currently the principal road link to the Niagara Peninsula and the State of New York via Lewiston, Niagara Falls and Fort Erie. With highway upgrading, the anticipated vehicular traffic on the Queen Elizabeth Highway adjacent to Windermere Basin should continue to increase. Subsequently the Windermere Basin, due to its location, will continue to be seen by larger numbers of visiting tourists, businessmen and commercial travellers each year. Under the existing conditions that can be observed in the Windermere Basin the visitor can not be expected to be favourably impressed.

5.2 Physical, Biological and Chemical Characteristics

Windermere Basin has been created through landfilling in the northeasterly end of Hamilton Harbour. This landfill has eliminated the natural marshland that previously surrounded this area of the harbour. Water depths in the basin have been reduced through sedimentation to the current levels which range from zero to approximately one metre. The sediments are predominantly fine grained inorganic and organic particles. An area of 20 hectares (one half of the area of the basin) is filled with sediments to above the normal low water level (MOE 1982). The sediments are composed of layers of soft black material overlying brown silty sand.

The 1987 report 'The In-Place Pollutants Program' by the Ontario Ministry of Environment stated:

"At some stations with heavily contaminated sediments such as Windermere Basin and St. Marys River, there appeared to be a toxic influence on biota. Although the sediment provided a suitable physical substrate, it was devoid of organisms."

The contaminants in the basin have contributed to degrading the chemical quality of both the sediments and the overlying water in Windermere Basin. Generally, the chemical analyses of Windermere Basin sediments indicate high levels of heavy metals, organics (loss on ignition and total organic carbon), greases and oils and chlorinated hydrocarbons including PCB's. Envirosearch (1985) studied water quality data from the Windermere Basin and found that quality of the overlying

water column changed as the water flowed through the basin. The quality of water was found to initially deteriorate as it flowed into the basin and came into contact with the highly contaminated sediments. Near the exit from the basin, water quality improved to a level generally of better quality than existed on entry to the basin. Under storm conditions and high flows, the exit quality was poorer than the incoming quality.

5.3 Quantity and Quality of Sediments to be Removed

The 1982 Windermere Basin Study indicated that the most contaminated sediments were confined to the upper 70 centimetres of the basin and made up a volume of approximately 280,000 cubic metres (measured over the entire basin).

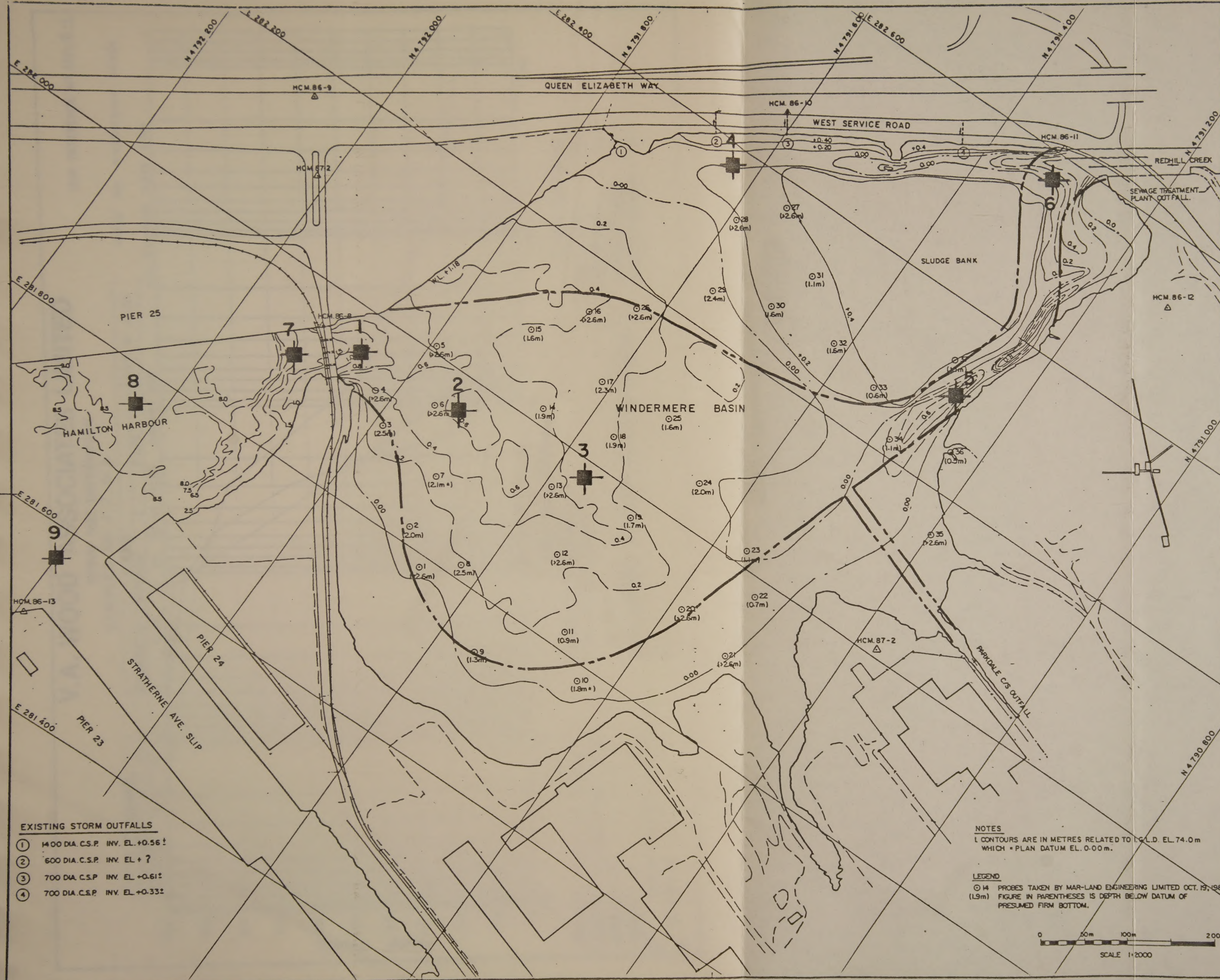
The recommended 'partial dredge and fill' alternative attempts to minimize the required dredging by locating a confined sediment disposal area to coincide with the major sludge deposits in the southeast portion of the basin. The remainder of the contaminated sediments located within the proposed open water area are to be removed along with underlying deposits to an average depth of 1.0 metres in the inlet channel and 1.5 metres in the remaining open water areas. A portion of this open water area is to be deepened to 4.0 metres to provide additional sediment trap capacity that will extend the useful life of the basin as a sediment retention area following a clean-up. Depths are quoted

depths below the 74.0 metre chart datum level.

By locating the containment areas where the worst sludge accumulations have occurred, the volume of contaminated sediment that must be removed is reduced. The 347,760 cubic metres of sediment to be removed in this project includes the contaminated sediment and underlying material to the 1.0 metre depth in the inlet channel and 1.5 metre depth in the open water area. The additional materials to be excavated for the proposed sediment trap (to a depth of 4.0 metres) total 112,900 cubic metres. The depths quoted are depths below the 74.0 metre chart datum.

Sediment samples were collected in Windermere Basin and analysed for grain size distribution by V.A. Wood Associates Limited as part of the preliminary engineering design work for the project. The samples were collected from seven locations as indicated in Figure 13. The grain size distributions are shown in Figures 14 and 15.

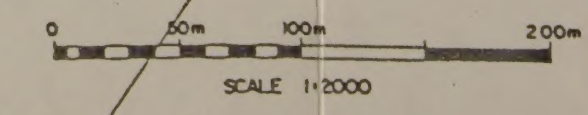
At the inlet channel to the basin (Fig. 13 - location #6), the sediments were found to consist predominantly of fine sands with lesser portions of medium sands, silts and a small percentage of coarse sands. Within the basin, at the discharge end of the proposed inlet channel (Fig. 13 - location #5), the sediments consisted predominantly of fine sands plus silt and clay materials with a small percentage of medium sands.



- EXISTING STORM OUTFALLS
- ① 1400 DIA. C.S.P. INV. EL. +0.561
 - ② 600 DIA. C.S.P. INV. EL. + ?
 - ③ 700 DIA. C.S.P. INV. EL. +0.612
 - ④ 700 DIA. C.S.P. INV. EL. +0.332

NOTES
1. CONTOURS ARE IN METRES RELATED TO I.C.L.D. EL. 74.0m
WHICH = PLAN DATUM EL. 0.00m.

LEGEND
① 14 PROBES TAKEN BY MAR-LAND ENGINEERING LIMITED OCT. 19, 1987.
(1.9m) FIGURE IN PARENTHESES IS DEPTH BELOW DATUM OF
PRESUMED FIRM BOTTOM.



Public Works Canada / Travaux publics Canada
Ontario Region / Région de l'Ontario

The Hamilton Harbour Commissioners

MAR-LAND ENGINEERING LIMITED
CONSULTING ENGINEERS

MARSHAM ONTARIO

A detail no. no. du détail	
B	Drawing no. - where detail required dessin no. - où détail requis
C	Drawing no. - where detailed dessin no. - où détaillé

project title
titre du projet

HAMILTON ONTARIO

IMPROVEMENTS TO
WINDERMERE BASIN

drawing title
titre du dessin

**BOTTOM SAMPLE
LOCATIONS.**

designed by
conçu par

drawn by
dessiné par

revised by
révisé par

approved by
approuvé par

project date
date du projet

project no.
no. du projet

drawing no.
dessin no.

Fig. 13

V.A. WOOD ASSOCIATES LIMITED

GRAIN SIZE DISTRIBUTION

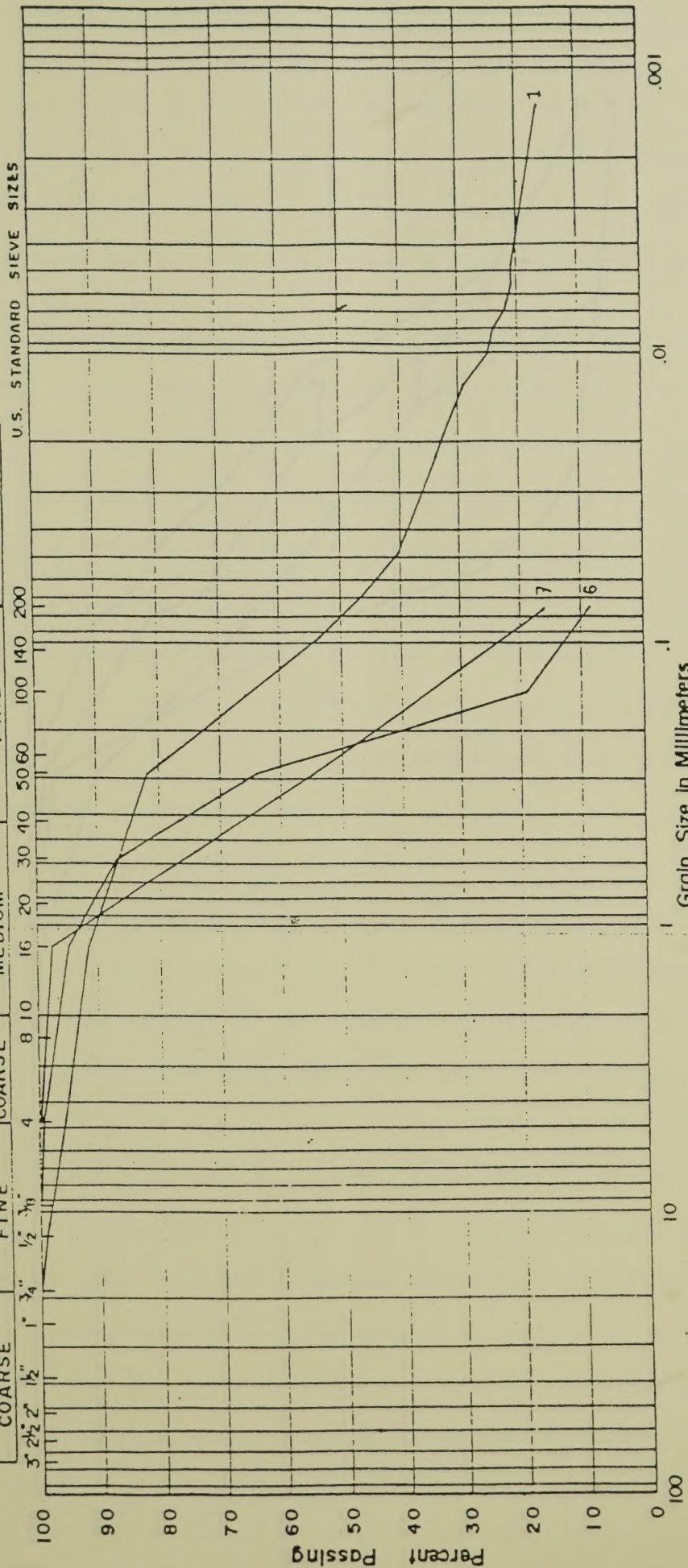
SAMPLES No 1, 7, & 6

OUR REFERENCE No 1316-8-1

UNIFIED SOIL CLASSIFICATION SYSTEM

SILT & CLAY

GRAVEL		SAND		FINE	
COARSE	FINE	COARSE	MEDIUM	COARSE	FINE
3" 2 1/2" 2" 1 1/2" 1" 3/4" 3/8"	3/16"	4"	8" 10" 16" 20" 30" 40" 50" 60" 100" 140" 200"	4"	8" 10" 16" 20" 30" 40" 50" 60" 100" 140" 200"



PLASTIC PROPERTIES

LIQUID LIMIT % =

PLASTIC LIMIT % =

PLASTICITY INDEX % =

MOISTURE CONTENT % =

COEFFICIENT OF UNIFORMITY :

COEFFICIENT OF CURVATURE :

Classification of Sample and Group Symbol:

PROJECT: HAMILTON HARBOUR

LOCATION: WINDERMERE BASIN

BOREHOLE No 1

SAMPLE No 1

DEPTH: BOTTOM DEPOSITS

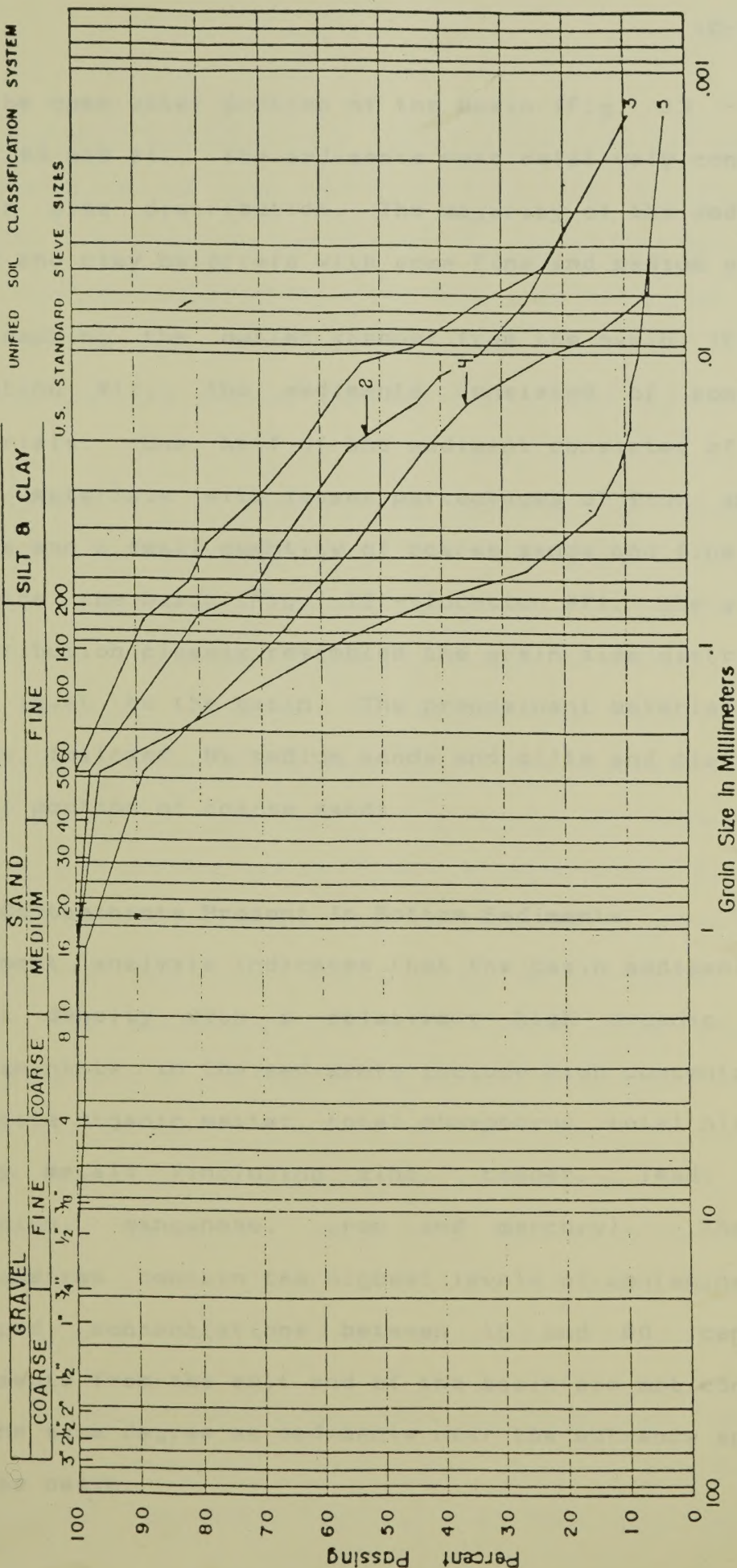
ELEVATION: 14

GRAIN SIZE DISTRIBUTION
SAMPLES N° 2, 3, 4 & 5

OUR REFERENCE NO 1316-8-1

UNIFIED SOIL CLASSIFICATION SYSTEM

SILT & CLAY



PLASTIC PROPERTIES

LIQUID LIMIT % ϵ

PLASTIC LIMIT	% E
100	100
90	90
80	80
70	70
60	60
50	50
40	40
30	30
20	20
10	10
0	0

PLASTICITY INDEX	%
0-5	100
6-10	100
11-15	100
16-20	100
21-25	100
26-30	100
31-35	100
36-40	100
41-45	100
46-50	100
51-55	100
56-60	100
61-65	100
66-70	100
71-75	100
76-80	100
81-85	100
86-90	100
91-95	100
96-100	100

MOISTURE CONTENT %

COEFFICIENT OF UNIFORMITY:

COEFFICIENT OF CURVATURE :

Classification of Sample and Group Symbol:
--

PROJECT: HAMILTON HARBOUR

LOCATION: WINDERMERE BASIN

BOREHOLE N° 1

SAMPLE №:

DEPTH: BOTTOM DEPOSITS

ELEVATION:

In the open water portion of the basin (Fig. 13 - locations #2, #3 and #4), the sediments were relatively consistent in grain size distribution. The majority of the sediment was silt and clay materials with some fine and medium sands.

Approaching the outlet channel from the basin (Fig. 13 - location #1), the sediments consisted of some coarser materials. One half of the sediment consisted of silt and clay materials with lesser percentages of fine and medium sands and a small quantity of coarse sands and fine gravels. Outside the basin (Fig. 13 - location #7), the grain size distribution closely resembled the grain size distribution at the inlet to the basin. The predominant material was fine sands followed by medium sands and silts and clays with a small portion of coarse sands.

5.4 Contaminants Present In Bottom Sediments

Sediment analysis indicates that the basin sediments are of light density with a relatively high organic content. Contaminants in the sediments include high concentrations of volatile organic matter, total phosphorus, total nitrogen and heavy metals (including zinc, copper, lead, cadmium, chromium, manganese, iron and mercury). The top 16 centimetres contain the highest levels of contaminants with reduced concentrations between 16 and 60 centimetres. Sediments from the exit end of the basin are not contaminated to the same degree as sediments near the entrance and middle of the basin.

The sediment analysis data indicate that the contaminants are accumulating in the basin and that the contaminants are either not reaching the discharge area of the basin, or if the contaminants do reach the discharge area they are being carried through the outlet channel into the Strathearne Avenue Approach Channel and eventually to Hamilton Harbour.

5.5 Probability of Contaminants Leaching From Sediments

The Residue Management Section of the Wastewater Technology Centre of Environment Canada undertook a series of tests (WTC 1986) for the Windermere Basin Technical Advisory Committee. The physical, chemical and leachability characteristics of sediment from the Windermere Basin were determined. As part of the testing, the Ontario Ministry of Environment standard leaching procedure was performed to determine the 'hazardous' or 'non-hazardous' nature of the sediment in accordance with the Ontario Regulation 309 under the Environmental Protection Act. The Wastewater Technology Centre batch leaching test was also used to determine the potential contaminant mobility from the sediment by simulating the process of scouring that would occur during high run-off or storm periods or during dredging. Lysimeter leach tests were performed to simulate different field disposal conditions including conditions of open water disposal and water saturated confined disposal.

The Wastewater Technology tests confirmed that the sediments were not 'hazardous' under the Ontario Regulation 309 definition. The batch leaching test identified the potential

for the contaminants to be mobilized when mixed with the water column as part of the dredging process, however, the lysimeter leach tests indicated that once the sediments are placed in a confined disposal facility there will be little potential for the contaminants to be transported through the groundwater back into the adjacent Windermere Basin.

The Wastewater Technology Centre tests confirm the need for the dredged sediment from Windermere Basin to be disposed in a confined disposal facility. The tests also confirm the need for isolating the dredging activities during the removal of the most heavily contaminated sediments.

5.6 Existing Condition of Flora and Fauna

As previously indicated, the Ontario Ministry of Environment (Persaud et al. 1987) collected sediment samples from the Windermere Basin that were devoid of benthic organisms despite the fact that the sediment provided a suitable substrate for a benthic community. The authors hypothesized that the absence of benthic organisms was due to the toxic nature of the sediments. However, Dobos and Weseloh (1987) have indicated that large numbers of benthic invertebrates exist in Windermere Basin. These opposite findings suggest that a range of conditions could exist in the basin.

In their report 'Historical Review of Hamilton Harbour Fisheries' (Holmes 1984), Holmes and Whillans comments related to Windermere Basin state that despite the historical

presence of "extensive marsh area, excellent spawning, nursery and adult habitat" there are presently only "small areas of marsh left" and "substrate mostly mud". They conclude that the rehabilitation potential of Windermere Basin for a fishery is low.

In 1985-86 and the fall of 1987, the Canadian Wildlife Service investigated incidents of waterfowl mortalities in the populations wintering in Windermere Basin. In the 1985-86 incident, test ducks (placed in Windermere Basin after mortalities in the wild duck population) showed signs of metals poisoning, the poisonings were not positively linked to the basin. In the 1987 incident wild ducks were said to be infected with botulism.

Currently, populations of flora and fauna in Windermere Basin exist under stress. Discussions with officials of the Canadian Wildlife Service and the Hamilton Naturalists Club have addressed the need for making provision for waterfowl where possible. These concerns are being addressed within the limits of the current project.

5.7 Functional Linkages Between Sediment, Water and Biota

It has previously been reported that there is evidence that contaminants in the Windermere Basin sediments are on occasion scoured from the bottom sediments into the water column. Envirosearch (1985) calculations indicate the definite risk of major sediment scouring from Windermere Basin if a 'Regional Storm' were to occur.

Ontario Ministry of Environment reports identify the probable current patterns for water discharging from the Windermere Basin as being along the north shore of the Hamilton Harbour toward the Burlington ship canal and lake Ontario. Investigations have also identified occasional current patterns that have resulted in Hamilton Harbour water impinging upon both the Hamilton and the Burlington water intakes on different occasions.

Extrapolating the findings from previous studies, it is realistic to assume that the contaminants in Windermere Basin could be broadly dispersed throughout the Hamilton Harbour and even gain access to the waters of western Lake Ontario given the correct sequence of events.

The testing on the Windermere Basin sediments has shown that contaminants associated with the sediments could be taken up in the water column if the sediments are resuspended. As long as the contaminated sediments in the Windermere Basin remain in the basin, only the ecology of the basin is impacted. However, should the contaminated sediments be transported from the basin ecological impairment could result in the areas in which the sediments are deposited. This area of impairment could include the water, sediments and biota in sections of Hamilton Harbour and western Lake Ontario.

When the basin is dredged, the average depth will be in the order of 2 metres. This greater depth of water will mean that the basin is not as attractive to some waterfowl. This can

be a problem, however, it would be possible to eventually mitigate this problem by modified habitat although this may be beyond the scope of the current project.

A decision has been taken to accomodate the population of waterfowl that frequent the Windermere Basin, but not at the jeopardy of the clean-up of the basin. Two problems exist with providing waterfowl habitat as part of the existing project. The first concern relates to the need to ensure that contaminants from the basin are contained within the confined disposal facility. The disposal facility berms will be constructed as proposed and monitored following completion of the project. The berms are being constructed such that if contaminants are found to be migrating through the berms, subsequent to the completion of the project then additional impervious material could be placed on the basin side of the berms to stop any contaminant loss. This would be more difficult to accomplish if the proposed changes to berm design were included to accomodate waterfowl at this point in time. The second problem with providing waterfowl habitat is related to the project funding in that the existing Windermere Basin Rehabilitation Project budget does not provide funds for creating wildlife habitat. The foregoing does not prevent the development of waterfowl habitat, but it does dictate that the project be completed and the berms be found to be secure against the migration of contaminants from the confined disposal facility and then it dictates that wildlife interests should initiate projects to raise the

required funding to complete the modification of shorelines within reasonable limits to provide improved waterfowl habitat.

The fact that the major portion of the flow through the basin is from the sewage treatment plant remains a cause for concern. The effluent from the sewage treatment process is likely to contain a number of pathogens some of which could infect the waterfowl population.

The following description of the work is presented in terms of elevations in feet relative to the International Great Lakes Datum 1985. The total length of the wastewater basin is 74.5 miles. The average depth and the water levels for Wastewater Basin are in the order of 74.5 and 100 feet respectively.

4.1 CONTAINED WASTEWATER BASIN CONSTRUCTION

The contained wastewater basin is to be constructed as a closed containment vessel around the perimeter of each disposal area. The basin is to be constructed by and owned by the local government and is to be constructed and maintained at the expense of the local government. The following sections discuss specific aspects of basin construction.

6.0 PROJECT ENVIRONMENTAL IMPACTS AND MITIGATION

The potential environmental impacts associated with the development of the project are discussed below. The project has been developed as a staged work programme that permits the removal of the worst contaminants in closed environments. The impacts are categorized in accordance with the various actions involved in the implementation of the project. Adverse impacts are identified and the specific mitigative measures that can be employed to minimize these impacts are described.

The following description of the work is presented in terms of elevations in metres related to the International Great Lakes Datum (1955). The chart datum used for Windermere Basin is 74.0 metres. The normal high and low water levels for Windermere Basin are in the order of 74.9 and 74.4 metres respectively.

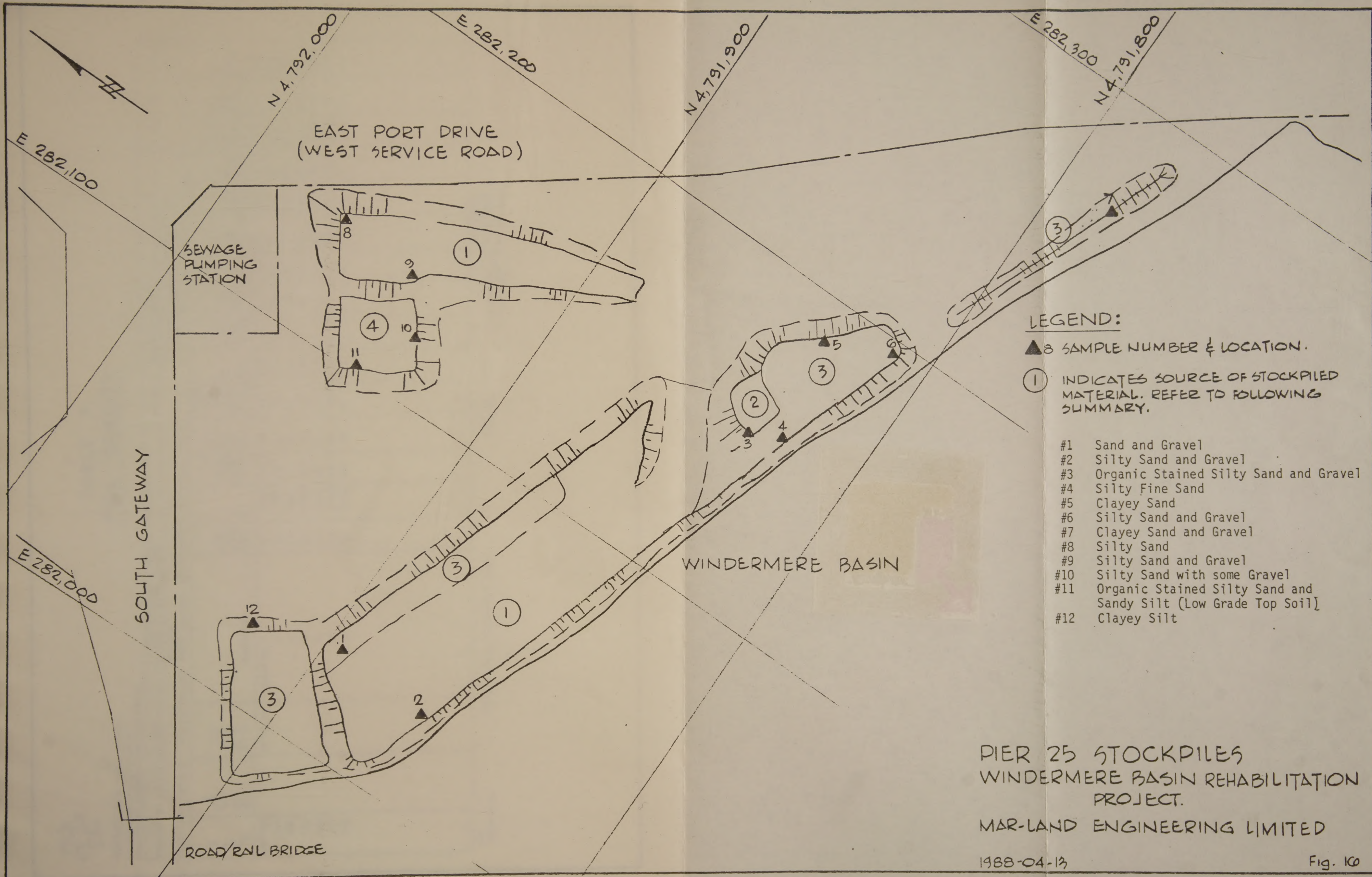
6.1 CONFINED DISPOSAL AREA BERM CONSTRUCTION

The confined disposal areas are to be constructed by placing containment berms around the perimeter of each disposal area. The berms are to be constructed by end dumping earth-fill and displacing and/or compressing the underlying soft sediment as the berm is constructed. The following sections discuss specific aspects of berm construction.

6.1.1 Stockpiled Material for Berm Construction

The Hamilton Harbour Commissioners have provided land adjacent to the Windermere Basin for a work and storage area from which to initiate the basin clean-up. The Commissioners are currently surcharging this portion of Pier 25 in preparation for its future use. The stockpiled fill material being used in the surcharging operation at this site will be made available to the project at no cost following the completion of the surcharge operation in June or July. This fill will be used in the construction of berms for the confined disposal facilities required for the contaminated sediment disposal.

A plan view of the stockpiled material is presented in Figure 16. The stockpiles were tested to determine the suitability of the material for berm construction. Quality data from the stockpile sampling programme is presented in Table 3. As a result of these tests, it was determined that the west section of the stockpile in the north corner of the storage area should not be used for berm construction. This material was removed from the storage area. Some of the material along the northeast side of the same stockpile was found to contain elevated levels of lead, copper and zinc. The levels were high enough to render this material unsuitable for the construction of berms that would be in contact with the open water. However, the material is suitable if its use is restricted to the construction of the interior berms required to create cells within the individual disposal





ENVIROCLEAN LONDON · TORONTO
A DIVISION OF MACLAREN PLANSERCH INC.
320 ADELAIDE STREET SOUTH, LONDON ONTARIO M5Z 3J2 (519) 686 7558

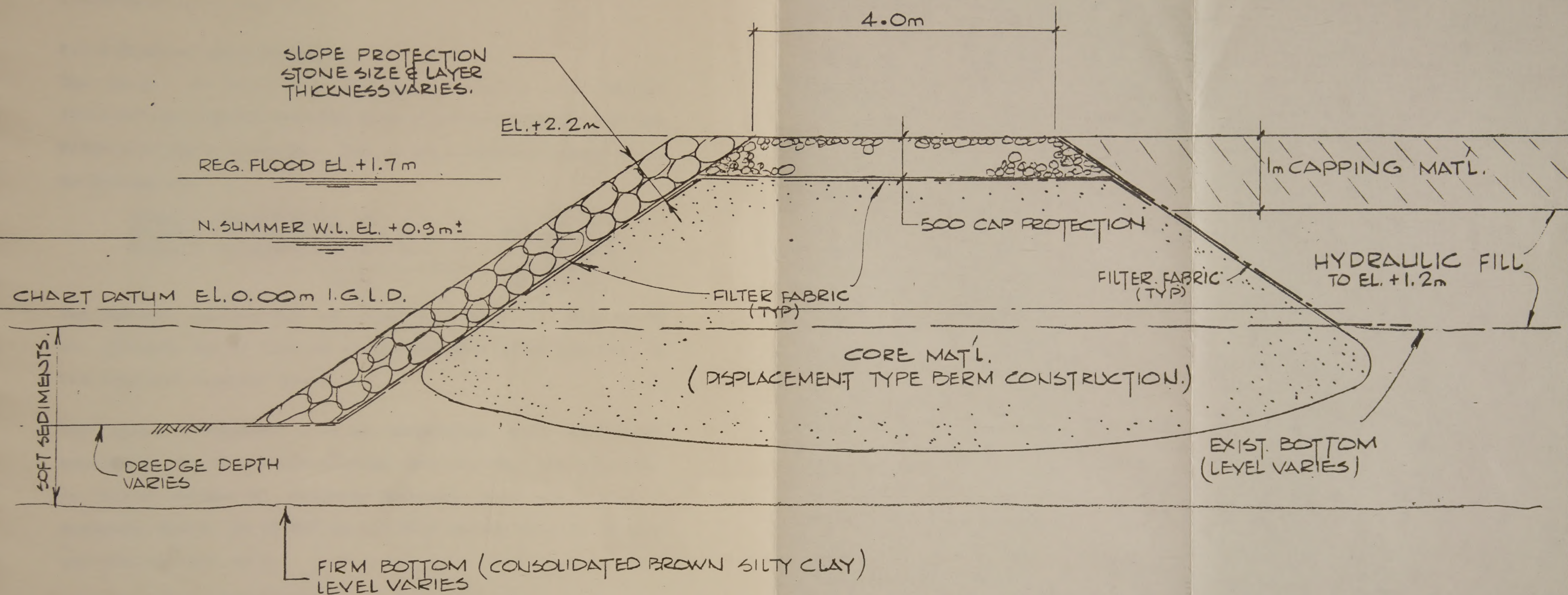
TABLE 3 FILL QUALITY

PROJECT NO.: 43120-A7-050000 CLIENT: 151 Nashdene Rd., Unit #2, Scarborough, Ont. V.A. Wood for P.W.C. Toronto																		
SOURCE: Sediment Samples																		
Windermere Basin Stockpile																		
ANALYTICAL RESULTS - Milligrams per XXXXX (except XXXXX and where stated)																		
SAMPLE NO.	DATE AND TIME TAKEN	DATE ANALYSTS COMPLETED	DESCRIPTION	Loss on Ignition @ 600°C	COD	Total Kjeldahl Nitrogen N	Total Phosphorus P	Total Oil & Grease (Hexane Soluble)	Cyanide CN	Total Arsenic As	Total Cadmium Cd	Total Chromium Cr	Total Copper Cu	Total Iron Fe %	Total Lead Pb	Total Mercury Hg	Total Nickel Ni	Total Zinc Zn
88/1180	-	28 Jan 88	Sample No. 1	2.3	8700	230	500	995	<0.03	4.9	0.2	18	23	0.82	22	0.10	7	155
1181	-	"	" 2	3.0	14550	340	620	730	<0.03	9.3	<0.1	30	38	2.2	58	0.06	10	120
1183	-	"	" 4	1.1	5900	100	765	50	<0.03	3.1	<0.1	26	24	2.2	20	0.12	6	48
1184	-	"	" 5	3.2	9800	260	630	135	<0.03	4.6	<0.1	46	44	2.4	16	0.12	18	82
1188	-	"	" 9	3.6	7800	520	805	660	<0.03	6.4	0.4	34	86	2.2	120	0.21	10	310
1190	-	"	" 11	6.2	32800	850	540	1250	0.30	4.3	1.1	82	100	3.0	120	0.28	46	500
1191	-	"	" 12	3.2	32700	420	735	70	0.16	4.2	<0.1	50	30	3.1	18	0.16	20	72

areas. The remaining material in the stockpiles was determined to be suitable for use in constructing the outer containment berms. More material is to be stockpiled in preparation for the berm construction phase of the project.

6.1.2 Typical Berm Construction

The containment berms for the confined disposal areas will be constructed by end dumping fill material to displace and/or compress soft sediment in the path of the berm. The core material for the berms is to be predominantly fine materials that will compact to be relatively impermeable. The berms are to be constructed with a sideslope of 1 to 1.5. The core material is to be constructed to a height of 0.5 metres above the hydraulic fill. The inner and outer surfaces of the finished berm cores forming the individual containment cells are to be protected with filter fabric that will be placed just prior to placing armour protection on or filling each cell. The top and Windermere Basin side of the berms are to be protected with rubble and rock placed over the filter fabric as required. The size of the rubble and stone will vary as required to provide the necessary protection against the scouring force that will be exerted on the berm by the water flow past the berm. For instance, the containment berm on the outside curve of the inlet channel to the basin downstream from the Redhill Creek will require heavier stone armour to be able to withstand the forces exerted by the streamflow during periods of high water flow, including situations such as the flood flows that could accompany a



TYPICAL SECTION

1:50

TYPICAL CONTAINMENT BERM
IMPROVEMENTS TO WINDERMERE BASIN.
MAR-LAND ENGINEERING LIMITED
CONSULTING ENGINEERS
420-100

regional storm. A typical section for a containment berm is illustrated in Figure 17.

6.1.3 Disposal Zone Volumes

The height of the containment berms is to be +2.2 metres (76.2 metres). Based upon the quantities calculations for the Windermere Basin clean-up, the in situ volume of material to be dredged is:

Stage 1 (to elevation 73.0 m.)	>>	10,600 cu.m.
Stage 2 (to elevation 72.5 m.)	>>	224,260 cu.m.
Stage 3 (to elevation 70.0 m.)	>>	112,900 cu.m.

TOTAL	>>	347,760 cu.m.

The sediment testing has indicated that there is likely to be an increase due to bulking of the sediment after placing in the confined disposal areas.

The stage 1 dredging is to be undertaken with mechanical equipment. At an assumed bulking rate of 10%, the resultant in place volume of disposed material from the stage 1 dredging would be 10,600 cu.m. This volume can be easily confined in cell No.1.

The stage 2 dredging is to be undertaken hydraulically. The available volume of cells No. 2 & 3 will be very close to the volume to be dredged. To maximize the containment cell capacity, cell No. 2 will be filled to 75.9 (+1.9) metres following which cell No. 3 will be filled to 75.9 (+1.9) metres. The dredged material placed in cells No. 2 and 3 is expected to consolidate approximately 10% leaving additional capacity to refill the cells to the 75.9 (+1.9) metre

elevation. At this point, the stage 2 dredging will be essentially complete.

The stage 3 dredging is to be undertaken hydraulically with the dredged material filling cells No. 4 to 8. The 112,900 cu.m. of dredged material will be placed in cells No. 5 to 8 first, keeping as much as possible of cell 4 available for future reserve capacity.

The clean-up of Windermere Basin is projected to utilize all available confined disposal capacity in cells No 1 to 3 and 5 to 8. The current estimates project the reserve capacity in cell No. 4, for future use, at 30,000 to 50,000 cubic metres.

6.2 STAGE 1

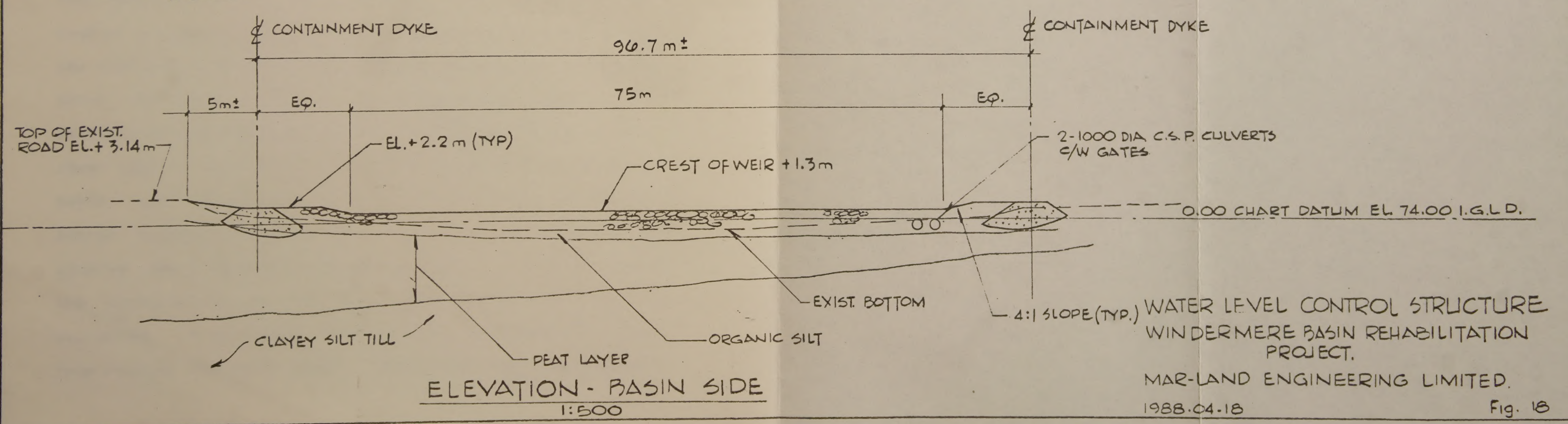
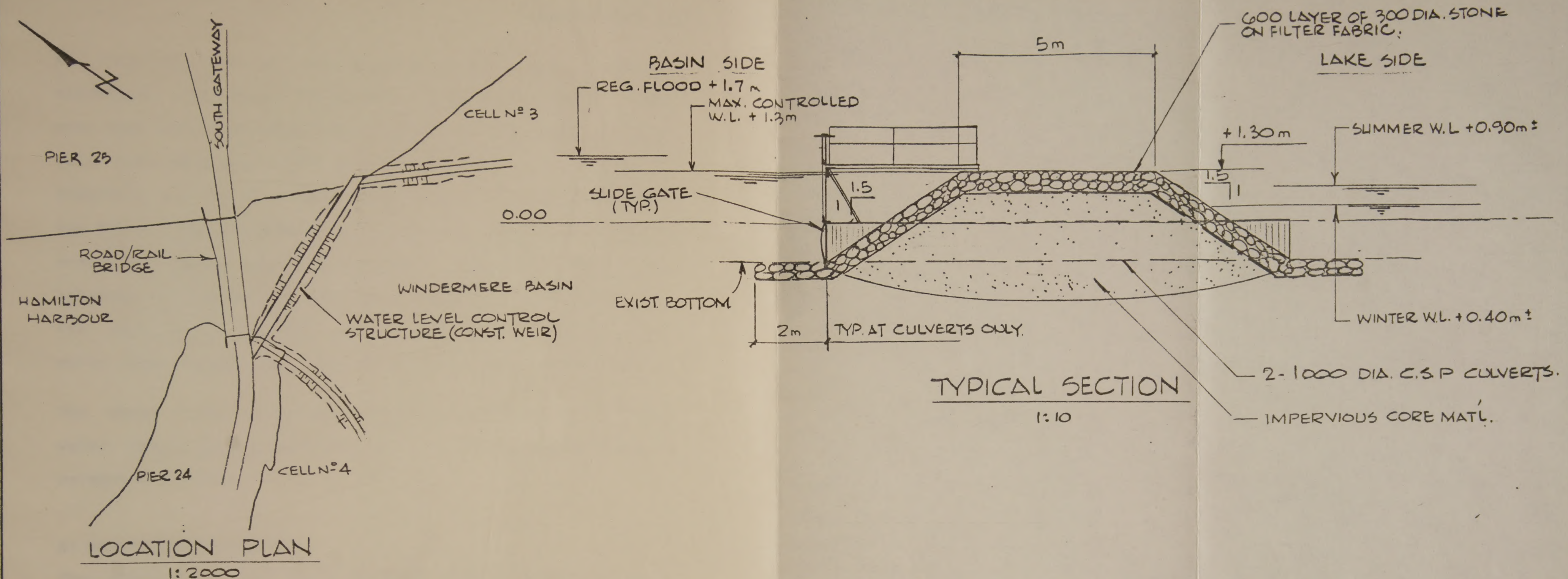
The stage 1 portion of the project involves the construction of a water level control structure southeast of the East Port Bridge plus the construction of containment berms that will form the inlet channel to the basin. The northerly of the two inlet channel berms will become part of the containment berm that will form the stage 2 disposal area cells No. 2 and 3 while the southerly berm in association with the existing shoreline will form the disposal cell No. 1.

6.2.1 Water Level Control Structure

The variations in water level in the Windermere Basin are related to the Hamilton Harbour and Lake Ontario water levels. The seasonal fluctuations in Lake Ontario levels are sufficient to result in prolonged periods when water depths

in Windermere Basin are inadequate to facilitate the manouvering of dredging equipment. To maintain water depths at a level suitable for the safe navigation of the equipment, a water level control structure is to be constructed southeast of the East Port Bridge. This structure will also serve to reduce the bedload sediment losses from the construction and dredging activities that will be associated with the project, especially during periods when construction and dredging have to be undertaken with the water flowing through the work area.

The proposed water level control structure will be a weir constructed as a stone lined, earth core mass berm with a portion of the centre section of the structure reduced in elevation to approximately 74.8 metres to facilitate water to overflow without eroding the structure. The weir berm will include low flow culverts that are placed through the berm at an elevation of approximately 74.4 metres. The culverts will be equipped with upstream flap gates that can be closed to raise the water level to overtop the structure or opened to lower the water level during the 1989-90 winter period or during high flow periods, if required. The structure is to be constructed to the southeast of the East Port Bridge between the existing landforms, its location is shown in Figure 10. A plan view, basin side elevation and typical cross section are presented in Figure 18.



WATER LEVEL CONTROL STRUCTURE
WINDERMERE BASIN REHABILITATION
PROJECT.
MAR-LAND ENGINEERING LIMITED.
1988.04.18
Fig. 18

At the location of the proposed water level control structure, the basin is underlain with layers of silt and peat that have been deposited on layers of clay/sand and clay till base material. The berm for the water level control structure will be end dumped from the east and west shores of the basin. The end dumping will displace and or compress the overlying layers of silt and peat. The berm weight is intended to provide the necessary compressive force to seal the peat layer that will be left in situ and thereby stop water from flowing under the water level control structure.

The water level control structure is designed to control water levels during construction. It is not intended as a permanent operating structure.

a) Environmental Impacts

The construction of the water level control structure will create a temporary adverse impact on the environment through the disturbance of bottom sediments, during and immediately after its construction. The contaminant level in the existing bottom sediments in the vicinity of the structure is lower than at locations in the southern portion of the basin, hence, the contaminant loss to the downstream Strathearne Avenue Approach Channel will be relatively minor. The adverse impact caused by the disturbance of sediments during the construction of the water level control structure is warranted. Significant benefits will subsequently result from raising the water level. Additional settling time will

be provided within the work area during the clean-up. In addition, the weir structure will trap bedload sediments that are disturbed and migrate through the basin thereby preventing them from reaching the Strathearne Avenue Approach Channel.

Following its construction, the water level control structure will make it possible to maintain the water levels in the basin in the order of 74.9 metres, the approximate high water level in Lake Ontario and Hamilton Harbour. Ontario Ministry of Environment data indicates that at the 74.9 metre level, the volume of the Windermere Basin is in the order of 510,000 cubic metres. By comparison, the Ontario data indicates the volume of the basin at the 74.4 metre low water level to be 184,000 cubic metres. Given the average daily flow through the basin of 405,000 cubic metres the water level control structure could increase the mean residence time of water in the basin from .45 days to 1.3 days. This increase in residence time would result in the reduction of flow velocity to approximately 36% of the mean velocity expected to occur at the low water level. The net benefit would be to reduce the risk of sediment scour and to increase the amount of settling that can take place prior to the water passing into the Strathearne Avenue Approach Channel.

The work that must be done to remove the seriously contaminated sediments from the Windermere Basin will inevitably result in the disturbance of considerable quantities of sediment that will then be moved along the

bottom by the water currents as a bedload. The water level control structure provides an additional benefit in that a significant portion of the sediment passing through the basin as sediment bed load will be retained within the basin by the structure.

b) Mitigation

The construction of the water level control structure is a necessary 'first step' in initiating the clean-up work for the Windermere Basin. To minimize the amount of sediment loss arising from the construction of the structure, the construction work should ideally take place during periods of low flow. Fill should not be dumped during storms or other events accompanied by high rates of streamflow. By restricting berm construction to periods with low flow conditions the flowthrough velocity in the basin will be at a minimum and there will not be as great a problem with sediment resuspension as would occur during periods when higher flows exist.

6.2.2 Confined Disposal Area -

Cells No. 1 and 2 Berm Construction

During the stage 1 work, the berms that will define the new inlet channel to the basin will be constructed (see Fig.10). This channel will eventually carry the streamflow from Redhill Creek and the effluent from the Woodward Avenue Sewage Treatment Plant west to the south of the large sludge bank that is located in the south end of the basin. During

this stage of construction all berms will be constructed by end dumping.

A temporary berm will be constructed from the shore at the west side of Redhill Creek to divert flow toward the north along the northeast shore of the Windermere Basin. The berms that will define the inlet channel to the basin will be constructed with a temporary berm being constructed across the outlet end of the channel.

a) Environmental Impacts

The diversion of the total flow along the northeast shore of the Windermere Basin is likely to cause the resuspension of some of the sediment located in this area. This will have a temporary adverse impact on water quality.

The construction of the berms defining the inlet channel will result in the displacement of a quantity of highly contaminated sediment with the resuspension of a portion of this sediment. Most of the resuspended sediment is likely to settle in the open areas of the basin or be trapped by the construction weir.

b) Mitigation

If the water level control structure is completed and the water level in the basin is raised to the 74.9 metre level prior to the commencement of construction of the diversion berm that will force the Redhill Creek flow and the Woodward

Avenue Sewage Treatment Plant effluent along the north shore of the Windermere Basin, the current velocities will be kept low and sediment scour should be minimized. This will reduce the deterioration that will occur in the water quality, as the water flows over the sediment deposits, to a level that will permit water quality recovery in the deeper downstream sections of the basin prior to flowing over the water level control structure into the Strathearne Avenue Approach Channel.

6.2.3 Stage 1 Clean-up Dredging

The inlet channel will be dredged using a clam or other suitable mechanical equipment to 1 metre below the 74 metre datum (elevation of 73 metres). This will result in a channel depth ranging from 1.4 metres at low water to 1.9 metres at high water.

The volume of material to be excavated from the inlet channel is estimated to be 10,600 cubic metres. This material will be deposited in disposal Cell No. 1. The available volume in disposal Cell No. 1 is estimated to be 13,400 cubic metres.

a) Environmental Impacts

The excavation of the sediment within the inlet channel to the 73.0 metre elevation will be undertaken within a closed environment. There should be no impact on the water quality in the basin from this work, however, there is likely to be significant oxygen demand exerted on the water column within

the enclosed channel area when the sediments are disturbed. This could lead to anoxic conditions in the water column and produce some undesirable odours.

b) Mitigation

If the sediment oxygen demand in the inlet channel proves to be excessive and threatens to create a problem due to the generation of odours, it may become necessary to take remedial actions to control the odour. The required actions may be limited to a reduction in the rate of dredging or could involve specific remediation such as the aeration of the waters in the work area.

6.3 STAGE 2

The stage 2 portion of the project involves the construction of a containment berm around the future south and westerly perimeter of the basin that will be used to form a channel to divert all flows to the water level control structure. The berm will be the outer containment berm for Cells No. 4 through 8.

Containment berms will be constructed for disposal Cells No. 2 and 3 which will be used to confine the most heavily contaminated sediments from the clean-up dredging of the open portion of the basin. During this period of dredging, the water flow will be diverted through the south and westerly by-pass channel.

6.3.1 Confined Disposal Cells 2 to 8 Berm Construction

A containment berm will be constructed that will define the post clean-up south and westerly perimeter of the basin (see Fig. 11). This berm will be used in the stage 3 portion of the work to construct the confined disposal cells No. 4 through 8. For the stage 2 portion of the work, a temporary berm will connect the east shore of the basin at a point south of the water level control structure to the north end of the containment berm along the south and westerly sides of the basin. A second temporary berm will connect the easterly end of the southerly containment berm to the west end of the northerly inlet channel berm, constructed as part of the stage 1 work. The temporary berms at each end of the inlet channel will be removed, and a permanent berm will be constructed at the east end of the northerly inlet channel berm to divert all flow from Redhill Creek and the Woodward Avenue Sewage Treatment Plant through the inlet channel and around the temporary south and westerly channel. Drainage from the Parkdale Avenue combined sewer overflow will discharge to the temporary south and westerly channel. Drainage from the East Port Drive and the Queen Elizabeth Highway will be directed along the northeast shore of the disposal cells No. 2 and 3 to discharge to the inlet channel at the Woodward Avenue Bridge.

The containment berm and the interior berm for disposal Cells No. 2 and 3 (see Fig. 11) will be constructed.

The disposal cells No. 2 and 3 will receive the most heavily contaminated sediments from the clean-up dredging of the open portion of the basin.

a) Environmental Impact

The construction of the containment berm that will form the south and westerly by-pass channel is likely to cause resuspension of some of the sediment located in the path of the berm. This will have a temporary adverse impact on water quality. During the initial flow diversion period, it is expected that there could be scouring of light surface sediment that has accumulated along the south shore of the basin, particularly around the Parkdale outfall.

The construction of the containment berm and the intermediate berm for the disposal cells No. 2 and 3 will require the displacing of considerable quantities of seriously contaminated sediment. This is likely to cause the release of contaminants into the water column.

b) Mitigation

The stage 2 work should continue with water levels near the 74.9 metre level to maintain water currents at a low velocity.

By sequencing the work it will be possible to take advantage of the current regime and minimize the rate of loss of sediment. The stage 1 flow diversion along the northeast shore of the basin should be maintained and the south and

westerly containment berm constructed moving from east to west to north commencing at the west end of the northerly inlet channel berm. This work should proceed until the berm is near the west approach of the East Port Bridge. The temporary end berms for the inlet channel should then be removed. Until this point, the sediments disturbed by the berm construction will be isolated from the main water flow which has been diverted across the northern portion of the basin. Once the temporary end berms are removed, flow will start to follow the south and westerly channel. The completion of the east end of the inlet berm should then be undertaken which will divert all flow through the south and westerly channel. At this point, the north end of the south and westerly berm should be closed off by working west from the east shore of the basin. This sequence will divert the flow out of the basin and into the south and westerly bypass channel with minimum uptake of contaminants due to sediment resuspension.

With the basin isolated from the flow, the containment and interior berms for the disposal cells 2 and 3 can then be constructed with no impact on downstream water quality. However, the disturbance of the sediments during this phase of the berm construction could begin to bring about a dissolved oxygen deficiency in the basin. If this occurs, odour problems could begin to develop. If odour problems become severe, remedial measures may be required including the possibility of temporarily halting work.

6.3.2 Stage 2 Clean-up Dredging

The streamflow from Redhill Creek and effluent from the Woodward Avenue Sewage Treatment Plant will be bypassed through the south and westerly channel while the clean-up dredging of the Windermere Basin is undertaken. This approach will permit the use of hydraulic equipment with a minimum rate of sediment loss. The dredged sediments will be placed in disposal cells No. 2 and 3. The decant water from disposal cells No. 2 and 3 will be circulated back into the dredge area. This approach will effectively make the clean-up of the central portion of the basin a closed loop operation.

The contaminated sediments will be removed to 1.5 metres below datum (72.5 metres). This will result in a basin depth following removal of the construction weir of 1.9 to 2.4 metres at low and high water respectively.

a) Environmental Impact

The hydraulic dredging operation will undertake to move contaminated sediments that have poor settling characteristics. As a consequence, the water within the closed basin area will become very heavily contaminated with suspended sediment. This will deplete the dissolved oxygen levels within the basin. There is no evidence of great numbers of fish in Windermere Basin, however, any carp or other fish that might be present and become trapped in the

work area will most likely be killed. In all probability, odour problems will arise.

The contaminants in the sediments could become a hazard to waterfowl when they are suspended in the water column and prior to capping when they are exposed in the confined disposal areas. The current situation also poses a hazard for waterfowl.

b) Mitigation

If the odours produced during the dredging operation reach nuisance levels, it could become necessary to provide supplementary aeration using diffused air or mechanical surface aeration equipment or temporarily suspend dredging operations. Criteria will have to be established to determine when remedial measures for odour control are required.

If the construction activities do not frighten waterfowl away, discussions may be required with the Canadian Wildlife Service to determine a suitable approach to discourage the presence of waterfowl in the basin and the confined disposal areas during the course the clean-up operations.

6.4 STAGE 3

The stage 3 portion of the project involves the removal of the temporary berms that diverted flow around the south and westerly perimeter of the basin and the completion of the

placing of containment berms to create disposal cells No. 4 through 8. The water flow is to be directed back through the basin with discharge to Hamilton Harbour over the water level control structure weir. The Parkdale Avenue combined sewer outfall will be extended.

The disposal cells No. 4 through 8 will be used as the confined disposal areas for the sediments that will be dredged to construct the sediment trap in the open water portion of the basin. During this period of dredging, the water flow will be through the work area.

6.4.1 Flow Diversion To Central Basin

The temporary berms that completed the stage 2 flow diversion channel, including the berm south of the water level control structure from the east shore of the basin to the north end of the south and westerly containment berm and the berm connecting the west end of the northerly inlet channel berm to the easterly end of the south and westerly containment berm, will be removed to permit water flow to pass through the basin.

a) Environmental Impact

During the stage 2 work, the water flow was isolated from the work area. With the stage 3 work requiring the use of the disposal cells 4 through 8, the flow must be returned to the main basin. This will result in the movement of some sediment and contaminants, that have accumulated in the water

column during the previous work, being displaced from the basin. The basin should be left closed for a period of time, if required, to permit the water quality to improve prior to opening the berms and permitting flow through the central portion of the basin.

b) Mitigation

The maintenance of water levels at or near the 74.9 metre high water level during this phase of the work will minimize the water flow velocities and the rate of carryover of contaminants into the downstream harbour. If water quality conditions have deteriorated to unacceptable levels prior to diverting flow back through the basin, it may be necessary to allow the basin to recover for a period of time by permitting natural processes to upgrade water quality, or alternatively, introduce an aeration system into the basin to upgrade water quality to acceptable levels. It is anticipated that the water quality will improve quickly following the completion of the stage 2 dredging as sediment settles out of suspension and sun and wind action brings about natural aeration. The basin may take several days for the water quality to improve to acceptable levels for discharge to the harbour.

6.4.2 Parkdale Avenue Combined Sewer Outfall Extension

The southerly containment berm will be opened at the location of the Parkdale Avenue combined sewer outfall following which containment berms will be constructed to extend the outfall to the basin. The free flow of water and combined sewage

overflows must be assured during this work.

a) Environmental Impact

The main impact likely to occur related to the Parkdale Avenue combined sewer outfall is the water quality degradation related to combined sewer overflows during storm periods. Over time there is the likelihood that there will be solids accumulations in the extended outfall from the sewer bypass structure to the basin. Solids could eventually accumulate in the basin adjacent to the new outfall channel creating localized conditions similar to existing conditions.

b) Mitigation

The Region of Hamilton-Wentworth has introduced a programme to modify the plant operation practices at the Woodward Avenue Sewage Treatment Plant. This minimizes the frequency of bypassing as well as minimizing the quantity of pollutants lost when a bypass cannot be avoided.

A regularly scheduled clean-up of the extended outfall channel using vacuum trucks or other suitable equipment could reduce the accumulations of solids and pollutants that will be deposited in the channel. This in turn would reduce the long term solids loading on the basin. This type of maintenance is considered outside the scope of the Harbour Commissioners mandate and should be the responsibility of others.

6.4.3 Confined Disposal Cells No. 4 through 8 Construction

The east end of the southerly containment berm will be connected to the shoreline to complete the construction of the disposal cell No. 8. The northerly end of the berm will be extended to complete the disposal cell No. 4. The interior berms will be completed to construct the cells No. 4 through 7. The cells No. 4 through 7 will be equipped with weirs such that excess water from the dredging operation is decanted and allowed to flow through adjacent cells with the decant from disposal cells No. 4 and 8 discharging to the extended Parkdale Avenue combined sewer outfall.

a) Environmental Impact

This phase of the construction will involve the placement of clean fill material. Some sediment resuspension will occur when the containment berms are closed to create the disposal cells No. 4 and 8. The construction of the interior cell berms will have little impact on the basin water quality.

b) Mitigation

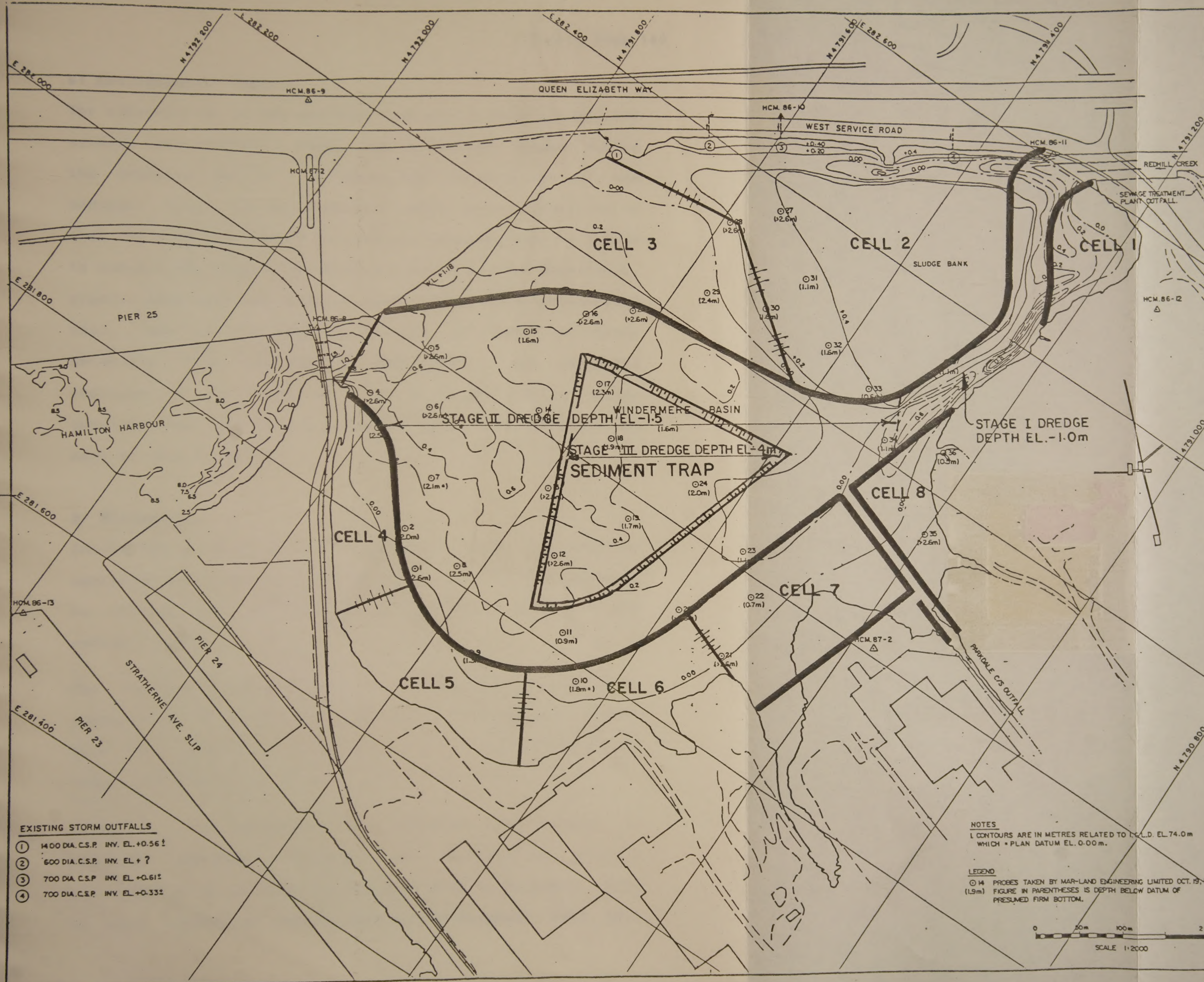
The maintenance of water levels in the basin at the 74.9 metre high water level will minimize water velocity and reduce the rate of sediment being carried over the water level control structure weir.

Berm construction work should be timed to avoid high flow periods including spring runoff and storms.

6.4.4 Stage 3 Sediment Trap Dredging

The stage 3 dredging involves the excavation of a sediment trap area in the basin to collect sediment being carried through the basin. The sediment trap is a deep section in the basin that is designed to catch the bedload sediment that is traversing the basin. In addition, there will be some reduction in flow velocity at the trap site thereby permitting additional settling of suspended solids from the water column. The sediment trap concept is presented in Figure 19.

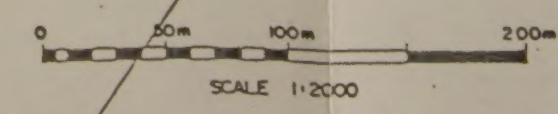
The trap will be excavated by hydraulic dredging and the dredged solids placed in the disposal cells No. 4 through 8. The material to be excavated for the sediment trap is better quality sediment compared to the surface materials that will be deposited in disposal cells No. 2 and 3. The trap excavation will be in the order of 112,900 cubic metres with the bottom of the trap being at 70.0 metres, approximately 2.5 metres below the surrounding basin floor. The sediment trap will be constructed so as to leave a shoulder of approximately 10 metres from the foot of the containment berms to ensure that the berms are not undermined. It may be necessary to construct spur dykes at a number of locations around the containment berms, after dredging is completed, to funnel the sediments into the sediment trap.



- EXISTING STORM OUTFALLS
- ① 1400 DIA. C.S.P. INV. EL. +0.561
 - ② 600 DIA. C.S.P. INV. EL. + ?
 - ③ 700 DIA. C.S.P. INV. EL. +0.612
 - ④ 700 DIA. C.S.P. INV. EL. +0.332

NOTES
1. CONTOURS ARE IN METRES RELATED TO C.L.D. EL. 74.0m WHICH = PLAN DATUM EL. 0.00m.

LEGEND
① 14 PROBES TAKEN BY MAR-LAND ENGINEERING LIMITED OCT. 19, 1987. (1.9m) FIGURE IN PARENTHESES IS DEPTH BELOW DATUM OF PRESUMED FIRM BOTTOM.

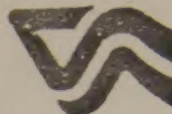




Public Works
Canada
Ontario Region



Travaux publics
Canada
Région de l'Ontario



The Hamilton
Harbour
Commissioners

MAR-LAND ENGINEERING LIMITED

CONSULTING ENGINEERS

MARHAMONTORIO

A
B
C

A detail no.
no. du détail
B drawing no. - where detail required
dessin no. - où détail requis
C drawing no. - where detail not required
dessin no. - où détail non requis

project title
titre du projet

HAMILTONONTARIO

drawing title
titre du dessin

IMPROVEMENTS TO
WINDERMERE BASIN

SEDIMENT TRAP

designed by
conçu par

drawn by
dessiné par

rechecked by
vérifié par

approved by
approuvé par

project date
date du projet

project no.
no. du projet

drawing no.
dessin no.

Fig. 19

a) Environmental Impacts

The construction of the sediment trap will create a temporary adverse environmental impact due to sediment losses during the dredging period. Following the construction of the sediment trap, the environmental impact will be positive in that the trap will retain particulate material that is likely to contain pollutants including nutrients such as phosphorus, organic materials and chemical compounds. It is anticipated that, due to the ongoing efforts to remove pollutant materials from the aquatic environment, the sediments captured in the future will be of significantly better quality than the sediments being removed from the basin as part of this clean-up.

b) Mitigation

Should the sediment content in the basin around the dredging operation reach unacceptable levels, it may become necessary to utilize silt curtains to confine the spread of the sediment cloud.

The confined disposal cells No. 4 through 8 are being constructed to permit decanting water from adjacent cells. This will extend the travel distance of the sediment and reduce the quantities escaping back to the basin.

Recently, the technology has improved with respect to reducing sediment transport and controlling erosion associated with construction projects such as highways. Some of this technology can be used at the disposal area cell

decant weirs to further reduce the sediment losses back to the basin. The need for additional control efforts will have to be determined as the project proceeds.

6.4.5 Sediment Trap Life Expectancy

The positive benefits from the construction of the sediment trap including the isolating of sediments and related pollutants could be relatively short lived if some form of ongoing trap maintenance is not practiced.

The trap capacity is to be 112,900 cubic metres. The available data (MOE 1982) indicate that, as of the early 1980's, the rate of suspended solids loading on the Windermere Basin was 58,000 kilograms per day. The sediment densities were found to range from 1,170 to 1,650 kilograms per cubic metre with a mean density of 1,270 kilograms per cubic metre. Based on the 1980 to 1982 loading rates the 112,900 cubic metre trap capacity would become filled in 7.5 years. Only 16% of the above mentioned solids were found to be directly related to the Woodward Avenue Sewage Treatment Plant. Assuming a similar portion to be related to combined sewer bypasses, it is reasonable to assume that at least 70% of the suspended solids loading will continue. Much of the remaining solids burden is most likely related to upstream solids losses from soil erosion. These solids would probably be denser than sewage related solids, possibly in the order of 1,500 kilograms per cubic metre. Therefore, it is theorized that at least $(58,000 \times .7) / 1,500 = 27$ cubic

metres per day of suspended solids will continue to be discharged to Windermere Basin. At this rate, the sediment trap life expectancy is 12.6 years. It is assumed that without a major upstream erosion control program, the Windermere Basin sediment trap will have a life expectancy between 7.5 and 12.6 years.

The situation with the current proposed clean-up of the basin is that there is likely to be only 30,000 to 50,000 cubic metres of volume left for sediment disposal capacity following the completion of the proposed clean-up. This means that future clean-ups could require the establishment of some other sediment disposal facility.

6.5 SEDIMENT CONFINED DISPOSAL

The nature of the sediments in Windermere Basin dictates that confined sediment disposal be practiced. The proposed sediment disposal technique for this clean-up is discussed below.

6.5.1 Sediment Deposition in the Confined Disposal Facilities

The confined disposal facilities will be constructed with soils having a content of fine materials sufficient to minimize the loss of leachate water through the containment berms.

The confined disposal cell No. 1 is to receive sediment from the inlet channel that will be excavated using mechanical

equipment. such as a clam. The sediment will be brought to the proposed level and allowed to decant back to the inlet channel area. The cell will be capped during the winter period of early 1990.

The most critical sediment disposal area is cells No. 2 and 3. This area will receive the sediments with the highest level of contamination. The dredging activities will be undertaken such as to deposit the most heavily contaminated sediments in the disposal area first to ensure that the contaminants are buried as deep as possible. The dredge discharge piping will be located at selected spots in the disposal area to distribute the sediment as required. As indicated previously, these cells will be filled twice with a period between fillings to permit some sediment consolidation.

The disposal cells No. 4 through 8 will receive hydraulically dredged material that is less polluted than the material that will go to cells No. 2 and 3. As before, the discharge points will be varied to optimize the filling of the individual cells while minimizing the amount of sediment carried back to the Windermere Basin. An attempt will be made to place the most seriously contaminated sediment at the deepest sections of the disposal area. The filling of these cells will be undertaken such as to minimize the quantity of sediment placed in cell No. 4. This cell will be maintained with some reserve capacity to facilitate future sediment disposal.

6.5.2 Dewatering Sediment in the Confined Disposal Facilities

The sediment deposited in the confined disposal areas will have a high water content. This mix of sediment and water will take considerable time to decant to a sufficient degree to permit capping operations to commence.

The hydraulic fill will be placed to a level slightly below the top of the berms. Through a combination of evaporation and infiltration, the water will gradually separate from the sediment material enough to permit cover material to be placed on the disposal area. It is assumed that the dredge material will not be dewatered enough to permit capping material to be placed during the first winter after dredging. The schedule anticipates capping operations during the early portion of 1990 when the surface material is frozen enough to support equipment.

It may be possible to place a network of dewatering pipe to accelerate the decanting process by pumping water from the disposal area sediments after the sediment is placed and the initial decant is complete. If a pumped dewatering process is used, the pump effluent could be discharged to cell No. 4 where natural process will reduce the contaminants to acceptable levels for discharge to the basin.

6.5.3 Capping Confined Disposal Facilities

After the disposal area has been dewatered and allowed to consolidate for a period of time, the cover material can be

placed during winter conditions while the sediment surface is frozen. The anticipated timing for capping is early 1990. The earth material will be placed from the perimeter and internal berms. The material will be pushed toward the centre of each cell using a bulldozer. The speed of capping will be controlled by the rate of frost penetration into the capping material as it is placed.

The nature of the Windermere Basin sediments are such that a prolonged period of several years will be required after capping before the disposal areas are stabilized to the degree that they will support significant weight.

6.6 PROJECT SCHEDULING

It is estimated that the contract for the project can be awarded by August of 1988. This would facilitate construction commencing in September 1988. The stage 1 work could be completed during the fall of 1988 and the stage 2 work commenced. Stage 2 dredging would take place from December 1988 to March 1989. The cells No. 1, 2 and 3 would be dewatered through to the fall of 1989. The stage 3 berm construction and dredging would take place during the period from October to December 1989. Capping would be undertaken during January and February of 1990 and site clean-up and landscaping would be undertaken during the summer of 1990. A preliminary construction schedule is included in Figure 20.

PRELIMINARY CONSTRUCTION SCHEDULE WINDERMERE BASIN REHABILITATION PROJECT - HAMILTON, ONTARIO

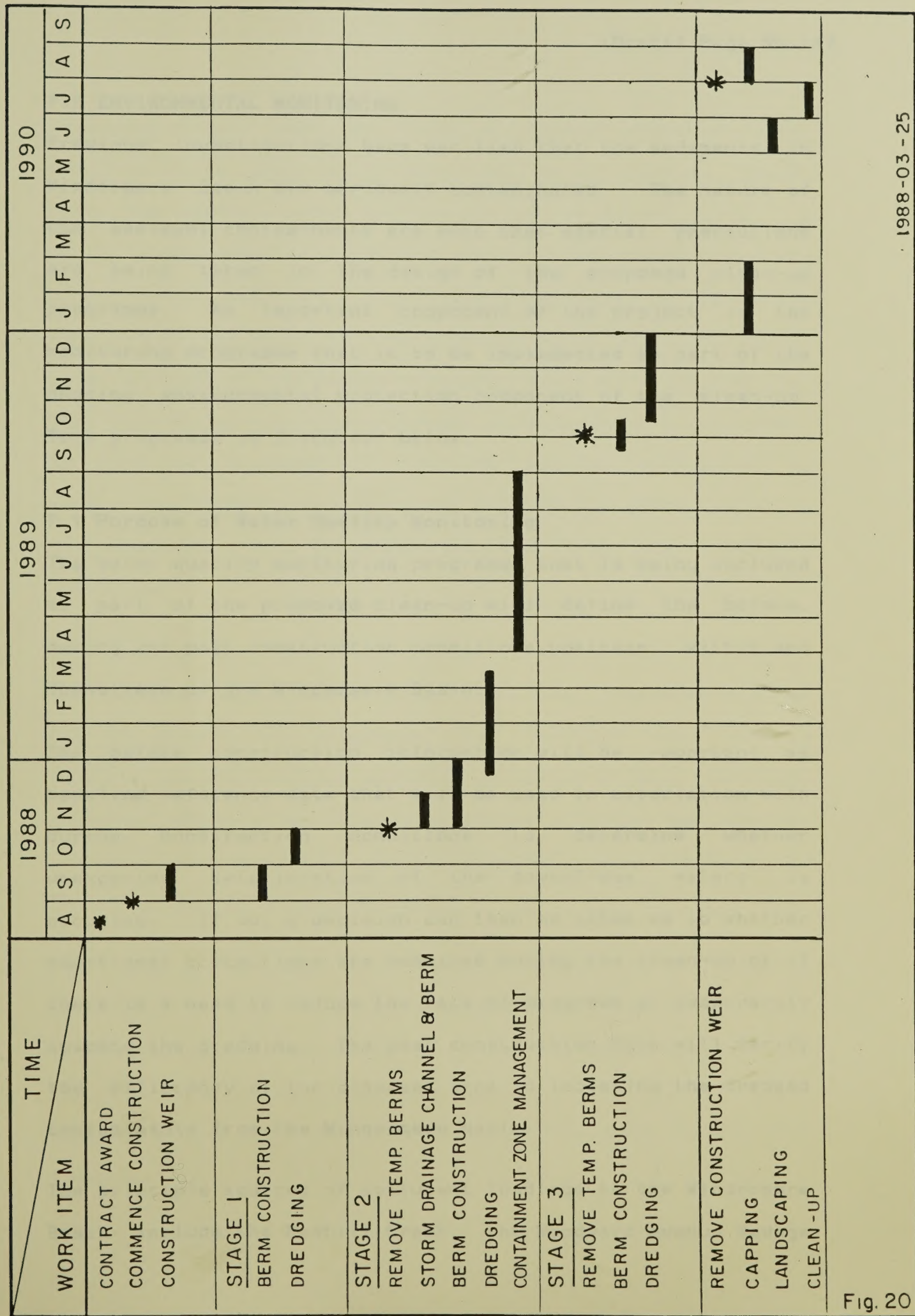


Fig. 20

7.0 ENVIRONMENTAL MONITORING

Previous investigations have verified that the sediments in Windermere Basin are seriously contaminated. The nature of the sediment contaminants are such that special precautions are being taken in the design of the proposed clean-up programme. An important component of the project is the monitoring programme that is to be implemented as part of the ongoing environmental protection component of the clean-up. This programme is discussed below.

7.1 Purpose of Water Quality Monitoring

The water quality monitoring programme that is being included as part of the proposed clean-up will define the before, during and post construction conditions upstream, within and downstream of the Windermere Basin.

The before construction information will be important as baseline reference data that will be used in association with during construction conditions to determine whether unexpected deterioration of the downstream waters is occurring. If so, a decision can then be taken as to whether additional precautions are required during the clean-up or if there is a need to reduce the rate of progress or temporarily suspend the dredging. The post construction data will verify the efficiency of the disposal area in isolating the dredged contaminants from the Windermere Basin.

The principle sources of pollutant loadings to the Windermere Basin include the Redhill Creek, the Woodward Avenue Sewage

Treatment Plant and the Parkdale Avenue combined sewer overflow. In addition to the normal daily loadings coming from the Redhill Creek and the sewage treatment plant, a major storm event or a process upset at the sewage treatment plant could generate a significant increase in pollutant loadings to the basin through combined sewer bypassing and/or deterioration of the sewage treatment plant effluent quality. The proposed monitoring programme associated with the clean-up must be designed to identify changes attributed to variations in background loadings such as the above examples as distinct from loadings arising from the dredging operation.

The Ontario Ministry of Environment, with the assistance of the Hamilton Region Conservation Authority, operates a water quality monitoring programme that includes the routine sampling of Redhill Creek upstream at Barton Street. Previous sampling data from this location can provide the typical normal level and the range over which water quality in Redhill Creek is likely to vary.

The Region of Hamilton-Wentworth operates a sampling programme at the Woodward Avenue Sewage Treatment Plant. This programme involves the daily collection of samples from the plant effluent that are analysed for BOD-5, total phosphorus and suspended solids with weekly sampling for free ammonia.

Discharge quality from the basin can be determined by sampling at the proposed water level control weir at the outlet from the basin or at the East Port bridge.

In situ loadings arising from the contaminants in the sludge can represent a significant load on the basin. In the case of Windermere Basin there have been considerable investigations to identify the spacial distribution of the sludge within the basin and the contaminant distribution within the sludge. Further before construction sampling would serve little benefit. The more important component of sampling will be to establish the sediment quality after the dredging work is completed.

The Ontario Ministry of Environment monitoring programme for Redhill Creek involves the monthly sampling of the creek. The analysis from this programme indicates that bacterial levels are consistently in violation of Ontario criteria. This plus the fact that a high percentage of flow through the Windermere Basin is from the sewage treatment plant makes the logic of bacterial sampling as part of the dredging monitoring programme questionable.

Other parameters measured as part of the Redhill Creek monitoring include:

- | | | |
|--------------------|------------------|-----------|
| - total phosphorus | - total Kjeldahl | - phenols |
| - iron | - arsenic | - mercury |
| - chromium | - copper | - lead |
| - cadmium | - zinc. | |

With the exception of PCB analysis, the background levels for the parameters suggested for monitoring are available through

the Redhill Creek monthly stream quality sampling programme.

The results of the previous investigations into conditions in Windermere Basin have been reported (MOE 1982, Envirosearch 1985). These studies have specifically presented information identifying conditions in the sediments in Windermere Basin. The previous information has confirmed that the sediments are highly contaminated and that the sediments are prone to scour during periods of high flows. The previous studies have also identified water quality trends across the basin. The existing information in these studies can be used to provide benchmark water quality information.

7.2 Before Construction Monitoring

Water quality conditions for low, medium and high flows can be determined using ongoing monitoring data and previous studies. These conditions would then be used as baseline data against which water quality can be measured during the dredging process.

One set of water quality data should be collected for comparison with the routine monitoring and previous studies data prior to the commencement of any berm construction or dredging activity. Should the data from this set of samples differ significantly from the expected levels of quality, an additional set of samples should be taken to confirm the 'before construction' conditions.

Water samples should be collected from Redhill Creek upstream from the Woodward Avenue Sewage Treatment Plant effluent plume, within the effluent plume and downstream from the Windermere Basin at the East Port Bridge. The samples collected should be analysed on a total sample basis for:

- | | | |
|--------------------|------------------|-----------|
| - total phosphorus | - total Kjeldahl | - phenols |
| - iron | - arsenic | - mercury |
| - chromium | - copper | - lead |
| - cadmium | - zinc. | |

Turbidity levels should be established at the two upstream locations and the downstream East Port Bridge location prior to any construction work commencing. No collections of sediment are necessary for purposes of establishing before dredging conditions.

7.3 During Construction

Turbidity measurements should be taken daily for the first week of construction with levels being monitored weekly thereafter until the first phase work is completed. The measurements should be taken at the two upstream locations (Redhill Creek and the STP effluent plume) and downstream at the East Port Bridge. The daily measurements should be resumed for the first week of work in each of the phase 2 and 3 portions of the work.

Preferably the turbidity measurements should be taken using a calibrated meter as compared to using in-place meters. The potential problem with in-place meters is that the electrodes are prone to become coated with silt and render false readings unless a continuous cleaning and calibration

programme is instituted.

Once construction starts, daily 24 hour composite samples should be collected at the two upstream locations and the East Port Bridge location. These samples should be held as a precaution in the event that there is some specific problem identified during the clean-up operation, in which case the appropriate samples could be analysed to determine the conditions at the time of the problem. If there is a specific problem indicated by high turbidity measurements during the clean-up, the East Port Bridge composite sample (for the day in question) could be analysed.

During the first week of dredging in the phase 2 and again in the phase 3 work, a portion of the daily composite sample from the East Port bridge should be analysed for suspended solids. These analyses should be compared to suspended solids samples taken at the final decant weir where the excess water in the sediment disposal area is decanted back to the Windermere Basin.

The sample analyses recommended above should be reviewed regularly and when definite trends are established, the frequency for analysing samples could be modified to reduce the number of analyses if warranted.

7.4 Post Clean-up

Following the completion of clean-up operations, samples should be collected at the two upstream and the downstream

sampling sites once a month (under steady state conditions) for 6 months. These samples should be analysed on a total sample basis for:

- | | | |
|--------------------|------------------|-----------|
| - total phosphorus | - total Kjeldahl | - phenols |
| - iron | - arsenic | - mercury |
| - chromium | - copper | - lead |
| - cadmium | - zinc. | |

In addition to the water quality samples indicated above, a set of sediment core samples should be collected from the basin following the clean-up. A minimum of 4 core samples (located at the outlet of the discharge channel to the basin, at the outlet from the basin upstream from the construction weir and at the third points through the basin) should be analysed. The core samples should be analysed according to identifiable layers or in 10 cm intervals. The samples should be analysed for:

- | | | |
|--------------------|------------------|-----------|
| - total phosphorus | - total Kjeldahl | - phenols |
| - iron | - arsenic | - mercury |
| - chromium | - copper | - lead |
| - cadmium | - zinc | - PAH |
| - pesticides | - PCB. | |

7.5 Berm Monitoring

Following the construction of the berms, a number of level markers should be set along the berms and levels surveys should be undertaken regularly during the work period to check settlement rates along the length of the berms. This data should be recorded and plotted to track settling rates in the berms. After the completion of the clean-up, the berm levels surveys should continue as required for a minimum of

one month at which time a decision can be made as to the required frequency for ongoing berm level measurement. The berms should also be inspected for signs of failure or leakage.

Two piezometers should be installed in each of the north and the south disposal area containment berms. These piezometers should be sampled monthly during the 6 month post clean-up monitoring and the samples analysed for:

- | | | |
|--------------------|------------------|-----------|
| - total phosphorus | - total Kjeldahl | - phenols |
| - iron | - arsenic | - mercury |
| - chromium | - copper | - lead |
| - cadmium | - zinc | - PAH |
| - pesticides | - PCB. | |

The analysis should be compared to the Windermere Basin inlet and outlet samples to determine whether significant levels of contaminants are migrating through the berms.

8.0 ENVIRONMENTAL IMPLICATIONS

The proposed work will involve the clean-up of the Windermere Basin with one environmental cost being the reduction of the basin from a surface area in the order of 47 hectares to approximately 22 hectares. For this clean-up there is a loss of surface area. However, this loss is offset by the increase in basin volume at the 74.4 metre low water level from in the order of 231,000 cubic metres to 526,000 cubic metres, an increase of 295,500 cubic metres or 128%. At the 74.9 metre high water level, the increase in volume is from 495,000 cubic metres to 634,050 metres or 28%. The volume increase is an environmental benefit offsetting the surface area loss.

8.1 Supporting Remedial Measures

Following the clean-up work when the contaminated sediments have been isolated from the aquatic environment, there will be a need to take action to minimize the sediment and contaminant loading that will continue to accumulate in Windermere Basin. To accomplish this, it will be necessary to implement programmes to intercept contaminants currently entering both Redhill Creek and Windermere Basin. Programmes will be required to eliminate combined sewer overflows, and to ensure that all liquid wastes receive adequate treatment prior to being discharged to the environment.

The Hamilton-Wentworth Region and the City of Hamilton have commenced the development of programmes aimed at reducing combined sewer overflows and improving stormwater management.

These programmes will be required to offset the rate of increase in stormwater runoff due to urbanization. For instance, increases of 15 to 47 percent in the peak flows in Redhill Creek are likely to occur (Stormwater Management Study of Redhill Creek Watershed, City of Hamilton; prepared by Phillips Planning and Engineering) as urban development occurs within the watershed.

One area of major concern is the management of soils in the upstream areas of the Redhill Creek watershed. This includes farmland as well as other properties. Without improvements in sediment control, over 70% of the sedimentation occurring in Windermere Basin will continue. It will be critical that agencies such as the Ontario Ministry of Agriculture and Food and the Hamilton Region Conservation Authority utilize their mandates to grapple with the upland erosion problem if the Windermere Basin is to survive into the long term future.

Without accompanying programmes to clean up the discharge of sediment and contaminants to the Redhill Creek and Windermere Basin, a cleanup of existing contaminated sediments could be relatively ineffective as contaminants would continue to accumulate in the Windermere Basin and the existing problem could be occurring again within one or two decades.

8.2 Future Use

The proposals for the clean-up of the Windermere Basin have included discussions as to methods of enhancing the

attractiveness of the basin to waterfowl. Due to the open water in the winter, flocks of waterfowl overwinter in the area. The discussions that have been undertaken included requests from wildlife interests to have the basin modified to include gradual bottom slopes to permit the establishment of aquatic plants in an environment that would be conducive to waterfowl populations. There is concern as to whether the portion of the flow through the basin that is sewage treatment plant effluent could be cause for concern. Effluent from sewage treatment plants can contain pathogens that could infect waterfowl populations. The previous discussion in section 5.7 Functional Linkages Between Sediment, Water and Biota discusses the establishment of waterfowl habitat following the completion of this project.

As discussed in Section 5.7, the design of bottom contours to provide the requested conditions cannot be undertaken at this time. After the project is completed and all berms, slopes and bottom contours are finalized and stable, including the construction of spur dykes that may be required to tune the basin for trapping sediment, it should be possible to construct slopes to accomodate waterfowl. The type and location of slopes could then be investigated. This could include the use of spur dykes, if placed in the basin for flow control, to serve a secondary waterfowl habitat function by adding material to provide the desired slopes behind these dykes. This can not be acted upon until all work is completed and the basin is fine tuned for sediment control.

The present project does not include any funding allowance for these future modifications.

The end use of the confined sediment disposal areas is not addressed herein in that land use is governed by appropriate planning and zoning restrictions controlled by others. The use of the confined disposal facilities may have to be restricted in its potential uses by Environment Canada as a result of environmental concerns, depending upon the characteristics of the sediments placed in the facility. Environmental restrictions could be a major concern in setting end use criteria.

9.0 CONSULTATION WITH ENVIRONMENTAL/REGULATORY AGENCIES

- to be included following further discussions.

10.0 PUBLIC CONSULTATION

- to be included following open house session.

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